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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. V.

No. I.—JANUARY, 1888.

ORIGINAL ARTICLES.

I.—The Natural History of Lavas as Illustrated by the Materials ejected from Krakatoa.[1]

By Prof. John W. Judd, F.R.S., Pres.G.S.

SHORTLY after the great volcanic eruption at Krakatoa, in August, 1883, the Royal Society appointed a Committee to collect and sift the records of that remarkable outbreak and to study the effects which appear to have resulted from it. The investigation of the volcanic phenomena and of the materials ejected from the volcano having been committed to me, I have been led to some conclusions of considerable geological interest, the full discussion of which could scarcely find a place in the report which has been published by the Committee. It is these general results which I propose to discuss in the following communication.

For the opportunity of studying the different rocks of Krakatoa, I am indebted to many correspondents who have supplied me with the necessary materials, and especially to M. René Bréon, who visited the volcano shortly after the eruption.

The central crater of Krakatoa has always given vent to lavas of the same general type—namely pyroxene-andesites, or rather, as they should perhaps be called, dacites: though from a lateral vent a great mass of basaltic lavas and tuffs were ejected during one epoch in the past history of the volcano.

It is the pyroxene-andesites to which I especially desire to call attention; for their study, in connection with that of other rocks of the same class, suggests a number of very interesting generalizations. The pyroxenes contained in these rocks belong to two species. The most abundant is one crystallizing in forms belonging to the orthorhombic system, in the composition of which the base magnesia predominates over the lime; it is a *ferriferous enstatite* or *hypersthene*. The less frequently occurring pyroxene is one crystallizing in forms of the clinorhombic system, in which lime preponderates over the magnesia: it is a true *augite*. Not only do these two forms of pyroxene always occur together, but they are sometimes found intergrown with their corresponding crystallographic planes in parallel positions. From the predominating pyroxene in these rocks they

[1] A paper read at the Meeting of the British Association in Manchester (September, 1887).

are frequently described as "enstatite-andesites" or "hypersthene-andesites."

Now these andesites of Krakatoa have been very carefully investigated, both by chemists and mineralogists, during the last four years. The memoirs of Richard,[1] Renard,[2] Sauer,[3] Reusch,[4] Oebbeke,[5] Von Lasaulx,[6] Carvill Lewis,[7] Joly,[8] Bréon,[9] Waller,[10] and especially of Verbeek, Retgers, and Winkler,[11] leave us little indeed to be desired in this respect. We have not only a number of independent analyses of the rocks themselves, but also of each of the minerals contained in them; these having been isolated by the refined methods of modern petrography. Each of the minerals too has been submitted to searching optical investigations, so that there are few rocks of which we can be said to know the chemical composition and mineralogical constitution more thoroughly.

It very fortunately happens that there are several other rocks belonging to the same general type which have also been investigated in the same thorough manner. Those that I have especially chosen for comparison are (1) the ancient and modern lavas of Santorin which have been studied by Zirkel, Karl von Hauer,[12] and especially by Prof. Fouqué.[13] (2) The lava of Buffalo Peaks, Colorado, for the description of which we are indebted to Mr. Whitman Cross [14] of the U.S. Geological Survey, and (3) the more ancient but very similar lavas of our own Cheviot Hills, which have been so carefully studied and described by Mr. Teall [15] and Dr. Petersen.[16]

Now these rocks, coming from such widely different localities, all agree in the minerals of which they are made up. They all include crystals of several species of plagioclastic felspar, the most basic or those containing a large per-centage of lime being very abundant; there are in all of them two pyroxenes, namely, ferriferous enstatite and augite, the former being present in greatest quantity; and they all contain magnetite with some ilmenite. In addition to the porphyritic crystals of these minerals, there is a base or ground-mass sometimes consisting of a nearly pure glass, at other times of glass which has undergone a greater or less amount of devitrification, whereby it has passed into a more or less perfectly stony mass.

[1] Comptes Rendus, Seance du 19 Novembre, 1883.
[2] Bull. de l'Acad. Royal de Belgique, 3re ser. t. vi. (1883).
[3] Berichte der Naturf. Gesellsch. zu Leipzig, 1883, p. 87.
[4] Neues Jahrb. für Min. etc. 1884, bd. ii.
[5] *Ibid.* 1884, bd. ii. p. 32.
[6] Sitzg. d niedersch. Gesch. in Bonn, Sitz. vom 3 December, 1883.
[7] Proc Acad. Sc. Philadelphia, 1884, p. 185.
[8] Roy. Dublin Soc. n.s. vol. iv. p. 201.
[9] "La Nature," 13me. Année (1885), p. 373.
[10] Birm. Nat. Hist. and Microscop. Soc. Rep. and Trans. for 1883, p. vi (March, 1884).
[11] Krakatau, pp. 185-324.
[12] Neues Jahrb. für Min. etc. 1866, p. 769.
[13] Santorin et ses Eruptions, 1870.
[14] Bull. U. S. Geol. Survey, No. 1 (1883).
[15] Geol. Mag. Ser. II. Vol. X. pp. 100-109 and 252-263.
[16] Mikroscopische und Chemische Untersuchungen am Enstatitporphyrit aus den Cheviot Hills, Kiel, 1884.

That there is a very great similarity in the composition of the glassy basis of these various rocks is shown by the following analyses :—

	Glass of Santorin lava (Fouque).		Glass of Cheviot rocks (Ebers in Petersen).		Glass of Krakatoa (Calculated).	
Silica with Titanic acid.	71·5	...	71·1	...	72·8	(68·8)
Alumina	16·8	...	14·6	...	14·7	(15·9)
Oxides of Iron	0·8	...	3·3	...	1·8	(5·1)
Lime	0·8	...	2·9	...	3·4	(3·8)
Magnesia..................	0·7	...	0·3	...	1·0	(1·2)
Soda	7·4	...	2·4	...	4·1	(5·1)
Potash	2·0	...	5·4	...	2·2	(1·1)

The statement of these and subsequent analyses has been calculated independently of water and "loss on ignition," not that I regard these volatile materials as being unimportant, but because the methods adopted by different chemists for their determination are so various, that their inclusion would make the comparisons less satisfactory. The analysis of the Krakatoa-glass is calculated from the bulk analysis of the pumice, compared with that of the several crystalline constituents, the proportion of each of these being known. I have placed in brackets besides this calculated analysis the actual analysis made by Retgers; but concerning this last it must be remarked that it is the analysis of the glass of the dust which fell nearly a hundred miles away from the volcano, from which some of the lighter particles had been winnowed out in its passage through the atmosphere. Moreover, it was found impossible to separate the finer grains of magnetite from this glass, so that, as admitted by its author, the silica is too low, and the iron-oxides too high. The same remark probably applies, though perhaps in a less degree, to the analysis of the glass of the Cheviot-rocks.

A very obvious defect in our modern methods of petrographic nomenclature and classification is that they are based on a *qualitative* and not on a *quantitative* determination of the mineralogical constitution of the rocks. When the *relative proportions* of the mineral constituents of a rock are taken into consideration, as well as their *nature*, we are led to some very interesting considerations.

At present, so far as I am aware, we have no other simple method available for determining the relative proportions of the constituents of a rock than the one suggested by Sorby, that of drawing the outlines of crystals seen in section under the microscope, and then cutting out and weighing on a delicate balance the portions of paper representing each of the minerals. By obtaining a photograph instead of a drawing of the section, as was suggested by the late Sir Richard Daintree, one source of error in such determinations may perhaps be removed. Of course, if we have a bulk-analysis of the rock, and analyses of each of its mineral constituents, it is possible to calculate the proportions which these latter bear to one another.

By a series of determinations of this kind, checked in a great number of different ways, I have convinced myself that the constitution of the Krakatoa-rock may be represented as follows :—

	in one hundred parts by weight.		
Glass	90·0	...	(91·0)
Felspars	6·5	...	(6·0)
Enstatite	1·4	...	(1·36)
Augite	0·6	...	(0·64)
Magnetite	1·5	...	(1·00)

The estimate made by Retgers, which I have placed in brackets beside my own, was based on the study of a dust which fell at Buitenzorg. But this material cannot exactly represent the original rock, seeing that during the passage of the dust through the air, the magnetite and other heavy minerals tend to fall sooner than the glass, while, on the other hand, excessively fine particles of the latter are left behind in the atmosphere. Hence, the dust which falls at any particular point cannot possibly be taken as a fair sample of the whole mass of the rock.

The Krakatoa-rocks, it will be seen, consist of two very distinct materials, a crystalline portion making up one-tenth of the whole mass, and a colloid or glassy portion which forms no less than nine-tenths of the whole. The chemical composition of the whole rock and of these two constituents is as follows:—

	Composition of rock.		Composition of Glass forming 90 % of rock.		Composition of Crystals forming 10 % of rock.
Silica with Titanic acid.	70·0	...	72·8	...	48·7
Alumina	15·0	...	14·7	...	19·3
Oxides of Iron	4·0	...	1·8	...	18·0
Lime	3·7	...	3·4	...	6·9
Magnesia	1·3	...	1·0	...	2·5
Soda	4·1	...	4·1	...	3·8
Potash	1·9	...	2·2	...	0·8

Now all the other rocks, to which I have referred, consist of a crystalline and a glassy portion, and these have nearly the same composition as those two portions of the Krakatoa-rock. All the rocks contain the same minerals, felspar, enstatite, augite, and magnetite; the analyses of which yield very similar results. In all of them, too, the relative proportions of these several minerals do not appear to be very different from that we have found to exist in the Krakatoa rocks. I have already shown that the composition of the glass in these different rocks is not very dissimilar. Nevertheless the ultimate chemical composition of these various rocks, all of which are called by petrographers by the same name of "enstatite-andesite," or "hypersthene-andesite," is found to differ in the most remarkable manner.

This fact is illustrated by the following table:—

	Rock of Santorin dykes.		Buffalo Peaks lava.		Cheviot rocks.		Recent lavas of Santorin.		Rocks of Krakatoa.
Silica	51·8	......	56·6	......	64·5	......	67·4	......	70·0
Alumina	20·1	.....	16·2	......	16·3	......	14·8	......	15·0
Oxides of Iron.	11·6	......	9·3	.....	5·1	......	6·4	......	4·0
Lime	11·9	......	7·8	......	4·4	......	3·7	......	3·7
Magnesia	3·4	......	4·6	......	4·2	......	1·0	......	1·3
Soda	1·1	......	3·1	......	3·4	......	4·4	......	4·1
Potash	0·1	......	2·4	......	3·1	......	2·3	......	1·9

At one end of this series we have a rock which is *basic* in its

composition, at the other end one which is distinctly *acid*; while the others may be fairly classed as intermediate between those types. Yet all these rocks contain precisely the same mineral constituents, and the difference in their chemical composition is clearly due to the very different proportions in which their more basic constituents, the porphyritic crystals, are mingled with the acid material, the enveloping glass.

Of course any variations in the relative proportions of the different felspars, pyroxenes and of magnetite will to some extent modify the ultimate chemical composition of the rocks; but I am convinced that in all these rocks the proportion of the several minerals to one another does not vary very greatly; in all of them felspar-crystals greatly predominate over the pyroxenes and magnetite; and among the pyroxenes the orthorhombic enstatite is almost always more abundant than the clinorhombic augite.

Assuming, what is certainly not far from the truth, then, that the crystalline and glassy portions of these rocks have respectively the same composition in all of them, we can calculate from the data before us the relative proportions of the crystalline and glassy portions of each of these rocks. The result is as follows:—

	Glassy base (parts in 100).		Crystalline portion (parts in 100).
Most basic dykes at Santorin	10	......	90
Other dykes at Santorin	10—35	......	90—65
Buffalo Peaks lava	$33\frac{1}{3}$	......	$66\frac{2}{3}$
Cheviot-rocks	66	......	34
Recent lavas of Santorin............	80	......	50
Lavas of Krakatoa	90	......	10

It will be seen that at one end of the series we have the crystalline constituent nine times more abundant than the glass, and at the other end the glass nine times as abundant as the crystalline constituent. But in spite of this, the rocks according to the ordinary system of nomenclature, based on mineralogical constitution, must be called—and indeed have been called—by the same name, that of "hypersthene-andesite" or "enstatite-andesite."

Let us now turn our attention to another remarkable set of facts with respect to these lavas of Krakatoa. It is a very striking circumstance that all the materials ejected from the central vent of Krakatoa agree in a very marked manner in their chemical composition and mineralogical constitution, *both qualitatively and quantitatively*. They all contain about 70 per cent. of silica, and are composed of 90 per cent. of base, with ten per cent. of porphyritic crystals; these last consisting of plagioclase felspar, enstatite, augite and magnetite, always in nearly the same relative proportions.

Nevertheless, while presenting this almost absolute identity in chemical and mineralogical constitution, we find among these products of Krakatoa three distinct types of materials—exhibiting the most striking differences in their physical characters and in the mode of their behaviour during ejection. These differences are seen to be dependent on peculiarities presented by the base or ground-

mass of the rocks, the crystalline or porphyritic portions being the same in all three types.[1]

In most of the older ejections the base is of a dull reddish-grey tint, and stony texture. Under the microscope the glass of the base is seen to have undergone a great amount of devitrification, and to be filled by a mesh of microlites of felspar, pyroxene, hornblende and iron-oxides, between which minute portions of the glassy base are left. Frequently this base is cavernous, and in such cases the cavities are lined with beautiful crystallizations of quartz, tridymite and hornblende. These are probably the results of secondary alteration. The fact of water having percolated through the rock is shown by the more or less complete conversion of the magnetite into hydrated ferric oxide.

Associated with this porphyritic stony lava, we find a second type of rock, the base of which is of a jet-black colour and resinous lustre. This beautiful velvety black rock is an admirable example of a *porphyritic pitchstone,* and strikingly resembles the rock of the Cheviot Hills and some of the Santorin lavas. The base contains fewer microlites, but is crowded with crystallites, both belonites and trichites, and these not unfrequently, according to Retgers, form the variety of spherulites called by Rosenbusch "felso-spherites." The rock, moreover, often exhibits a fluidal structure.

In the third type of rock occurring at Krakatoa, we find the porphyritic crystals still the same, but embedded in an almost perfect glass, which is of a rich amber-brown colour when seen in large fragments, but almost colourless in thin sections by transmitted light. This rock has been called a *porphyritic obsidian.* Under the microscope, the glassy base of this rock is found to contain only a very few widely-scattered microlites and crystallites.

But the most striking difference between the base or ground-mass of these three types of lava becomes apparent when they are subjected to high temperatures. If a fragment of the stony lava or of the pitchstone be acted upon by a strong blowpipe-jet, urged by a foot-bellows, it may be rendered white-hot without exhibiting signs of fusion. But if we treat a fragment of the obsidian in the same way, we shall find that on approaching a white heat, it begins to melt, and in doing so swells up into a cauliflower-like mass, five or six times the size of the original. When this mass is cooled and examined, it is found to be a dirty brownish-white pumice, identical in all its characters with the material that was thrown out in such vast quantities during the last great eruption of Krakatoa. This identity in character is seen to be even more marked if we make thin sections of the natural and of the artificial products, and examine them under the microscope. In its behaviour the obsidian of Krakatoa behaves indeed precisely like the Marekanite of Okhotz and a glassy rock from Fife which I have previously described.[2]

[1] In the Report on "Krakatoa" by the Royal Society Committee, plates ii. and iii. are devoted to the illustration of the characters of the rocks of Krakatoa as exhibited in microscopic sections.

[2] Geol. Mag. Dec. III. Vol. III. (1886), p. 243. Quart. Journ. Geol. Soc. vol. xlii. (1886), p. 429.

In all these cases it is clear that the rocks contain a considerable proportion of volatile materials, which are given off at a high temperature.

When we come to study the several varieties of the lava of Krakatoa in the field, we are struck by remarkable differences in the mode in which they must have behaved while in a liquid condition. The stony lava and the pitchstone it is seen were extruded in massive lava-streams with an almost total absence of pumice or scoriæ; the obsidian, on the other hand, was almost wholly distended into a pumice, throughout which the porphyritic crystals of the rock are found entangled. It is evident that every part of the glass has been impregnated with the volatile constituents, which by their escape have caused its conversion into pumice, for the whole of the glass is drawn out into the finest rods and plates; indeed, it is only in the case of small fragments which have been suddenly cooled before the volatile ingredients have been permitted to escape, that we are able to judge of the characters of the glass from which the pumice was formed By cutting blocks of pumice of definite size, and comparing their weight with that of masses of glass of the same size (this being easily determined when the specific gravity of the glass is known), I have been able to calculate the amount of distension which has taken place in the glass during its conversion into pumice. The more compact varieties of pumice have 3½ times the bulk of the glass from which they were formed; in the more common looser varieties the distension has been at least 5½ times the original; and in some varieties the bulk of the air-cavities is 7, 8 or even 9 times that of the enclosing glass.

The stony lavas and the pitchstones differ mainly in the amount of devitrification which the glassy base has undergone. And this we have every reason to believe was determined by the rate at which cooling took place. We find indeed every gradation between the one type and the other, just as we do in the Cheviot Hills; at Steerhope, near Yetholm, in that district, a great lava-stream may be seen, the central portion of which consists of a stony rock, while the superficial layers graduate into well-known pitchstone. There can be little doubt that, in the same way at Krakatoa, the more rapidly cooled portions of the stony lava have formed the porphyritic pitchstone.

But the obsidian of Krakatoa presents many very striking differences from the other two kinds of rock; and for some of these the more easy fusibility of its base affords a ready explanation. Thus, little knots of the pitchstone are often found scattered through the obsidian; and in the pumice formed from the obsidian these stand out in relief upon the abraded surfaces, in the same way as do the porphyritic crystals. Now when such knots of pitchstone are examined microscopically, the felspars in them are found to have undergone a most wonderful amount of corrosion; often the larger part of their bulk has been redissolved in the heated magma in which they have been enveloped, they are completely honeycombed, and sometimes reduced to mere skeletons.

Those who regard the bulk-analysis of an igneous rock as necessarily representing the composition of the magma out of which the minerals which compose it have separated, and who further consider the successive crops of crystals formed in a rock as being determined by the alteration in the composition of the residual magma by the constant separation of the basic minerals from, it will find it difficult to harmonize such views with the facts presented to us at Krakatoa.

It is difficult, in the first instance, to account for the separation of precisely the same minerals, the felspars, pyroxenes and magnetite, in magmas of such diverse composition as is represented in the third table on page 4. On the other hand, it is a significant circumstance that the glass of the Krakatoa-lavas is sometimes found without the porphyritic crystals; pumice formed of this glass without any enclosed crystals was certainly erupted during the eruption in May, 1883. Similar facts are recorded by Fouqué in the case of the Santorin lavas. It must be remembered, too, that the whole of the lavas of Krakatoa, and perhaps of all the volcanoes on the line of cross fissure upon which it is situated, are of an exceptional character; the ordinary enstatite-andesites of Java containing only about 55 to 62 per cent. of silica, and having a much smaller proportion of glass to the porphyritic crystals. In Santorin, too, we have the same difference, though somewhat less marked, between some of the older and deep-seated dykes and the modern lavas of the volcano.

All of these facts point to the conclusion that after the partial separation of a magma into crystals and a colloid residue, the two may be separated by a process of liquation, and subsequently become mingled again in varying proportions. I need scarcely point out that the condition of many porphyritic crystals—eroded, broken, or frayed out in the magma in which they lie—are strongly suggestive of the same conclusion. These porphyritic crystals indeed have often the appearance of foreign materials which have been caught up by the magma in which they are now found.

It is a significant circumstance that the Krakatoa-rocks, and this is true of many other rocks of the same class, do not appear to have their porphyritic crystals scattered quite at hazard through their mass. On the contrary, the felspars, pyroxenes and magnetite are seen to form little knots often intercrystallized in the midst of the vitreous base. In this respect, there is an approach to the structure for which I have proposed the name of "glomero-porphyritic," in which we find what looks like the association of minerals typical of one class of rock scattered through a rock of a totally different class. In the typical example of the kind which I have described fragments of troctolite appear as if scattered through an ophitic dolerite.

In the case of the plutonic rocks of the Western Isles of Scotland, I have shown how frequently one or other of the constituents of a magma may segregate locally so as to give rise to a variety of rock in which this mineral predominates. In this way gabbros are found graduating in places into rocks essentially composed of olivine, pyroxene, or felspar.

If, as the consideration of these rocks at Krakatoa so strongly suggests, the minerals crystallized out of a magma, and the residuum of mixed silicates can be separated to a greater or less extent, and then recombined in fresh proportions, we have an explanation of the ejection from the same vent of materials differing most widely in their ultimate chemical composition, though presenting curious peculiarities in the enclosed minerals which are common to all of them.

It is almost impossible to study the older and more recent ejections from Krakatoa without being driven to consider the possibility of the latter as having been to a great extent formed by the refusion of the former. Indeed the existence of knots of the unfused black glass in the midst of the modern pumices, and portions of the same material clinging to the crystals embedded in the recent obsidian, seem to render the fact of this refusion all but certain. How this refusion might have been brought about, a few very simple considerations will, I think, enable us to understand.

The late Dr. Frederick Guthrie, whose early death was so great a loss to science, was engaged in a number of researches which have a very important bearing on questions of petrogeny, and are of great suggestiveness to the geologist. Solutions of various salts when cooled down are found to yield successive crops of crystals of ice or of the salt, until at last the remaining mixture of the two substances in a definite proportion are left behind, forming the bodies to which Dr. Guthrie gave the name of *Cryohydrates*. He subsequently showed that mixtures of metals or of salts behave in the same way when reduced to liquid condition by heat, and for those substances, compounds which separate out like the cryohydrates from a solution, he proposed the name of *Eutectic* bodies or *Eutectics*. The chief characteristics of these bodies is the lowness of their temperature of fusion.

Dr. Guthrie himself clearly saw the importance of these considerations to the geologist. We are continually dealing with mixtures of salts (silicates) from which a number of definite crystallized bodies have separated out, till at last a residuum is left which consolidates at a lower temperature than any of them. The determination of the nature and composition of these eutectic silicates is a problem of the very greatest interest to petrologists. In a still later memoir, one of the last which he wrote, Dr. Guthrie attacks a closely related question which is of even greater interest and importance to the geologist. That water plays an important part in the liquefaction of the igneous masses of the Earth's crust has been maintained by Scrope, Scheerer, Bischof, Daubrée, and many other observers, and cannot, indeed, be doubted by any one who has studied the phenomena attending the extrusion of lavas from a volcanic vent. But as to the exact *rôle* played by the water in such molten masses, there has been much difference of opinion, and the researches of Guthrie are of the greatest importance, as throwing new light on this very interesting question.

The influence of the presence of water in lowering the fusion

points of various salts is a question which was very carefully investigated by Guthrie. He showed that a certain mixture of the nitrates of lead and potash had its fusion-point reduced from 3° to 4° C. by the introduction into it of a quantity of water equal to $\frac{1}{555}$th part of its weight. Still more striking are the results obtained by the study of the fusion-point of nitre as influenced by the presence of water. The following table abridged from that given by Dr. Guthrie will serve to explain this subject :—

FUSION-POINTS OF MIXTURES OF NITRE AND WATER.

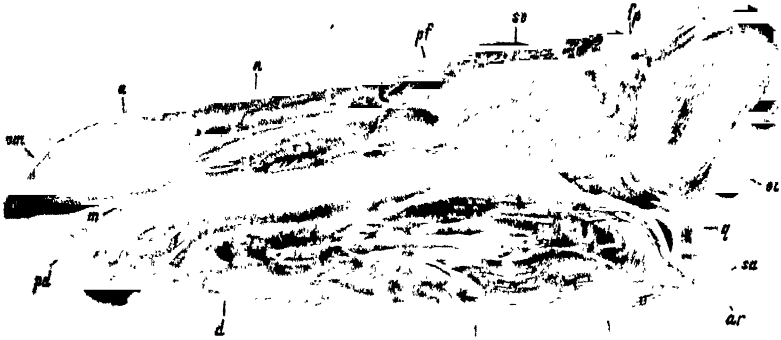
Nitre.		Water.		Fusion-point	
100	...	0	...	320°	C
98·86	...	1·14	...	300°	,,
95·11	...	4·89	...	262°	,,
89·94	...	10·06	...	201°	,,
84·69	...	15·31	...	151°	,,
70·14	...	20·86	...	123°	,,
75·02	...	24·08	...	115°	,,
70·03	...	29·07	...	97°·6	,,

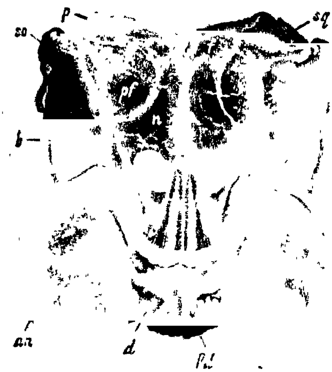
There is no question here of the formation of definite compounds of nitre and water, but in the words of Dr. Guthrie "fused nitre and fused ice are miscible in all proportions," the result of the increase of water being a proportional lowering of the fusion-points. "The phenomenon of fusion" is shown by Guthrie to be "nothing more than an extreme case of liquefaction by solution." Indeed, it is impossible to define where solution ends and fusion begins; when, for example, one part of water is present in 555 parts of a salt, it would be hard to consider the latter as dissolved in the former.

Now it is impossible to doubt for one moment that the presence of water has the same effect on the fusion-points of mixed silicates that it has on other salts, though owing to the high temperatures and pressures required, experiments on these are more difficult than in the case of salts of more easy fusibility. The Zeolites consist of mixtures of silicates of alumina and of the alkalies or lime, in the same proportions as in the Felspars; but while the former contain water, the latter are anhydrous; as is well known, the Zeolites fuse at much lower temperatures than the Felspars. Nor is this true only of definite compounds as is shown by studying the fusibility of such indefinite mixtures of silicates and water as the tachylytes, hydrotachylytes, palagonites, etc.

The consideration of these points leads to a clearer understanding of the method of action of water in volcanic vents. That there are serious objections to the notion of water giving rise to volcanic eruptions by finding its way through *open fissures* to masses of incandescent lava, has been pointed out by Scrope and other authors; and Daubrée and others have advocated the gradual percolation of water through the interstices of solid rock-masses as being an agency more in accordance with the phenomena observed. But it has always been considered necessary to assume a considerable rise in the temperature of the subterranean mass as one of the exciting causes of a volcanic outburst.

A careful consideration of the results arrived at by Dr. Guthrie's





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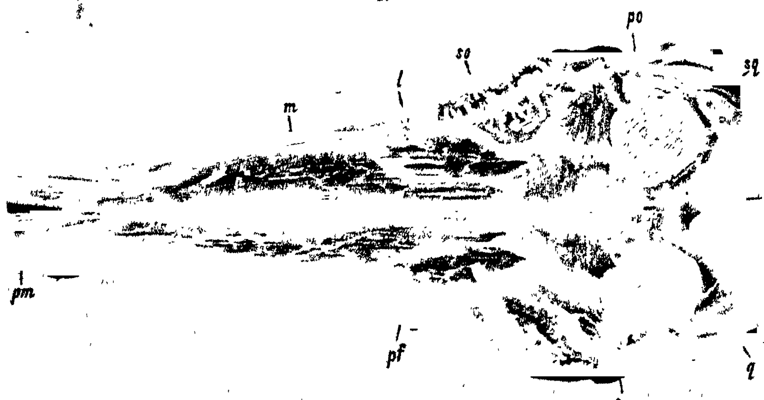


Fig. 1.—Skull of *Stegosaurus stenops*, Marsh; side view.
Fig. 2.—The same specimen; front view.
Fig. 3.—The same specimen; top view.
All the figures are one-fourth natural size.

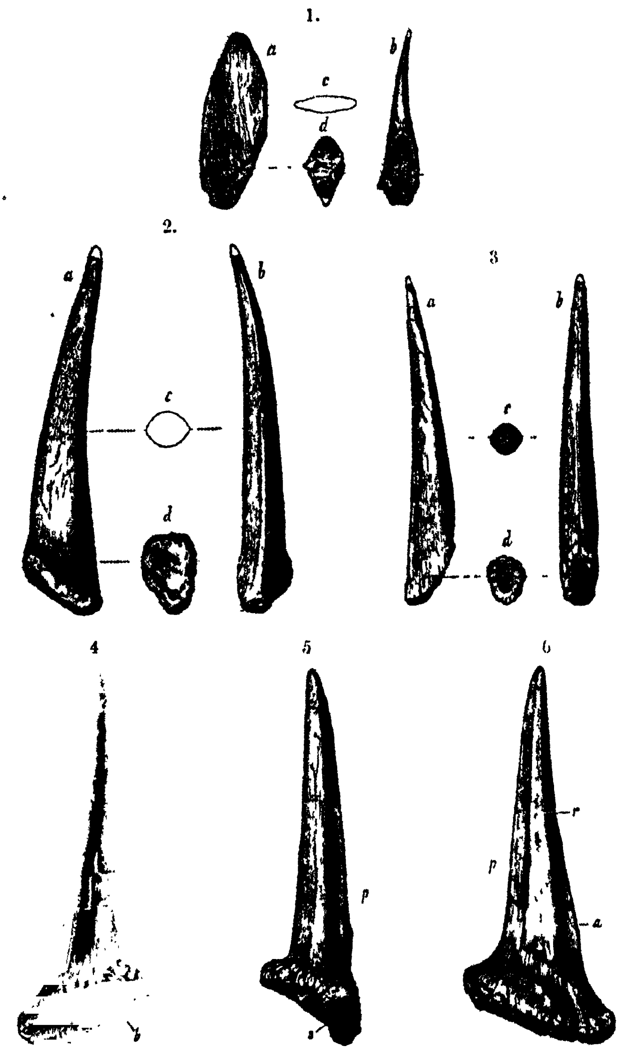
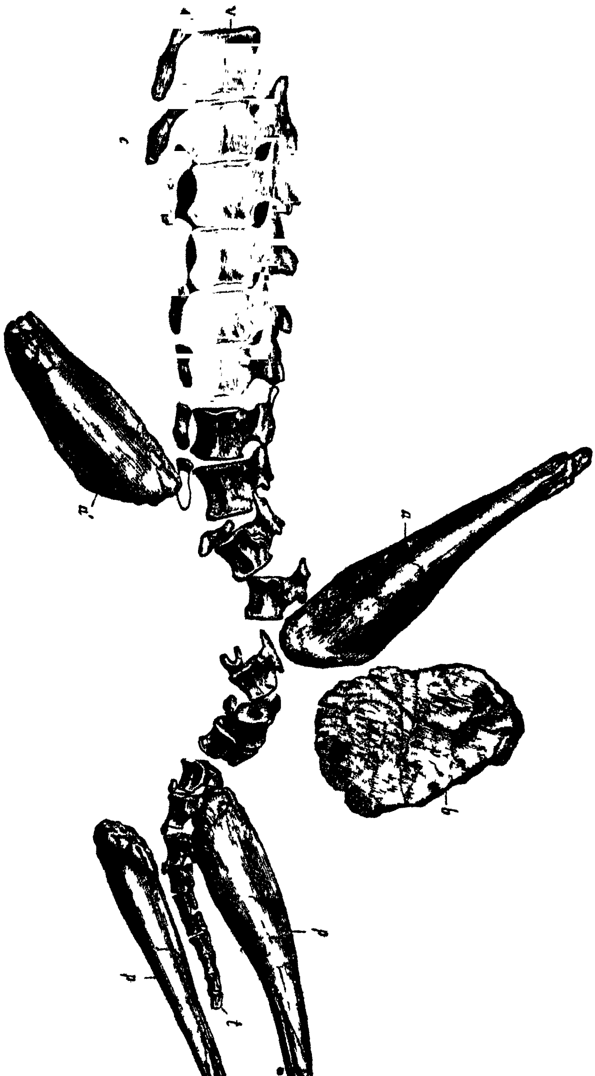


FIG. 1.—Dorsal spine of *Stegosaurus ungulatus*, Marsh; *a*, side view; *b*, posterior view; *c*, section; *d*, interior view of base.
FIG. 2.—Large caudal spine of same individual; *a*, side view, *b*, front view; other letters as above.
FIG. 3.—Smaller caudal spine of same individual; *b*, posterior view; other letters as above.
FIG. 4.—Caudal spine of *Stegosaurus sulcatus*, Marsh; side view.
FIG. 5—The same spine; posterior view.
FIG. 6.—The same spine; inner view.
All the figures are one-twelfth natural size.



udal vertebræ, spines, and plate of *Diracodon laticeps*, Marsh; seen from the left. One-sixth natural size. *a*, right anterior spine; *a'*, left anterior spine; *b*, small caudal plate; *c*, chevron bone; *p*, right posterior spine; *p'*, left posterior spine; *t*, terminal vertebra; *v*, median caudal vertebra.

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A careful consideration of the results arrived at by Dr. Guthrie's

researches serves to convince us, however, that such rise of temperature is by no means a necessary prelude to a volcanic outburst, but that the percolation of water to a centre of igneous activity is in itself sufficient to serve as an exciting cause. If we were to imagine a mass of solid nitre lying at some depth within the earth's crust, and having a temperature of 260° C., such a mass would be solid and inert. But if, without raising the temperature, a quantity of water, equal to five per cent. of the weight of the nitre, were introduced into it, then the whole would become liquid and the tendency of the heated water to relieve itself from the pressure might give rise to all the phenomena of a volcanic outburst. What is true of nitre is equally true of the mixed silicates composing lavas, which are at much higher temperatures. The admission of water to such a mass of mixed silicates at a temperature below its point of fusion would cause it to become liquid and thus give rise to the phenomena of eruption. In the case of the Krakatoa-lavas, the anhydrous varieties probably existed quite solid at tolerably high temperatures; but the gradual percolation of water into their mass (and the evidences of such percolation, are seen in the hydrated condition of the minerals composing it) would render the whole liquid, without the necessity for any rise in temperature.

II.—The Skull and Dermal Armour of *Stegosaurus*.

By Professor O. C. Marsh, Ph.D., LL.D.

(PLATES I. II. III.)

In various numbers of the "American Journal of Science," the writer has given the more important characters of the skeleton of the *Stegosauria*, and has indicated the relations of this group to the other known *Dinosauria*.[1] The discovery of additional specimens of *Stegosaurus*, one of them nearly complete, furnishes material to greatly enlarge our knowledge of the skull and dermal covering of this genus, and some of the new facts are given in the present article.

The results of the entire investigation of this group will be brought together in a monograph now in preparation, by the writer, for the United States Geological Survey. The lithographic plates for this volume, sixty-five in number, are nearly all printed, and the figures of the skull here given are taken from these plates.

The Skull. (Plate I.)

The skull of *Stegosaurus* is long and slender, the facial portion being especially produced. Seen from the side, with the lower jaw in position, it is wedge-shaped, with the point formed by the premaxillary, which projects well beyond the mandible, as shown in Fig. 1, Plate I. The anterior nares (*a*) are large, and situated far in front. The orbit (*b*) is very large, and placed well back. The

[1] "American Journal of Science," vol. xiv. p. 513, Dec. 1887; vol. xix. p. 253, March, 1880; vol. xxi. p. 167, Feb. 1881; vol. xxiii. p. 83, Jan. 1882; and vol. xxiv. p. 410, Nov. 1887.

lower temporal fossa (*c*) is somewhat smaller. All these openings are oval in outline, and are on a line nearly parallel with the top of the skull. In this view, the lower jaw covers the teeth entirely.

Seen from above, as shown in Fig. 3, Plate I., the wedge-shaped form of the skull is still apparent. The only openings visible are the supra-temporal fossæ (*e*). The premaxillary bones (*pm*) are short above, but send back a long process below the narial orifice. The nasal bones (*n*) are very large, and elongate. They are separated in front by the premaxillaries, and behind, by anterior projections from the frontal bones. The prefrontals (*pf*) are large, and are placed between the nasals and the prominent, rugose supra-orbitals (*so*). The frontals are short, and externally join the post-frontals (*fp*). The parietals are small, and closely coössified with each other.

Viewed from in front, the skull and mandible present a nearly quadrate outline (Pl. I. Fig. 2), and the mutual relations of the facial bones are well shown. In this view is seen, also, the predentary bone (*pd*), a characteristic feature of the mandible in this genus. The lateral aspect of this bone is shown in Fig. 1.

The teeth in this genus are entirely confined to the maxillary and dentary bones, and are not visible in any of the figures here given. They are small, with compressed, fluted crowns, which are separated from the roots by a more or less distinct neck. The premaxillary and the predentary bones are edentulous.

The present skull belongs to the type specimen of a very distinct species, which the writer has called *Stegosaurus stenops*. The skull and nearly complete skeleton of this specimen, with nearly all the dermal armour in place, were found almost in the position in which the animal died.

This animal was much smaller than those representing the other species of this genus. Its remains were found in the Atlantosaurus beds of the Upper Jurassic, in Southern Colorado. In this geological horizon, all the known American forms of *Stegosauria* have been discovered.

THE DERMAL ARMOUR.

The osseous dermal covering of *Stegosaurus* was first described by the writer from specimens found associated with several skeletons, but not in place, and hence the position of the various parts was a matter of considerable doubt. Subsequent discoveries have shown the general arrangement of the plates, spines, and ossicles, and it is now evident that, while all the group were apparently well protected by offensive and defensive armour, the various species, and perhaps the sexes, differed more or less in the form, size, and number of portions of their dermal covering. This was especially true of the spines, which are quite characteristic in some members of the group, if not in all.

The skull was evidently covered above with a comparatively soft integument. The throat and neck below were well protected by small, rounded and flattened ossicles having a regular arrangement in the thick skin. One of these ossicles is shown in Woodcut Fig. 1.

The upper portion of the neck, back of the skull, was protected by plates, arranged in pairs on either side. These plates increased in size farther back, and thus the trunk was shielded from injury.

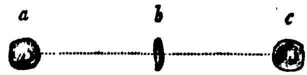


Fig. 1.—Gular plate of *Stegosaurus ungulatus*, Marsh; *a*, superior view; *b*, side view; *c*, inferior view.

From the pelvic region backward, a series of huge plates stood upright along the median line, gradually diminishing in size to about the middle of the tail. One of these is shown in Woodcut Fig. 3.

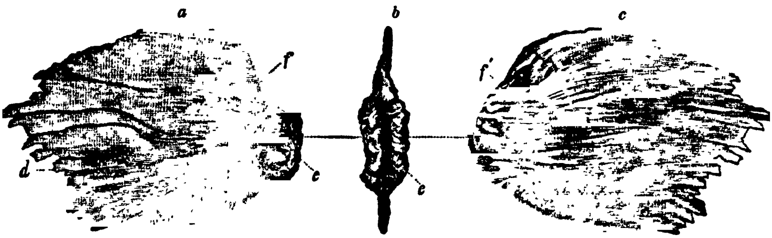


Fig. 2.—Caudal plate of same individual; *a*, side view; *b*, end view of base; *c*, view of opposite side; *d*, thin margin; *e*, rugose base; *f*, and *f'*, surface marked by vascular grooves.

Some of the species, at least, had somewhat similar plates below the base of the tail, and one of these bones is represented in Woodcut Fig. 2.

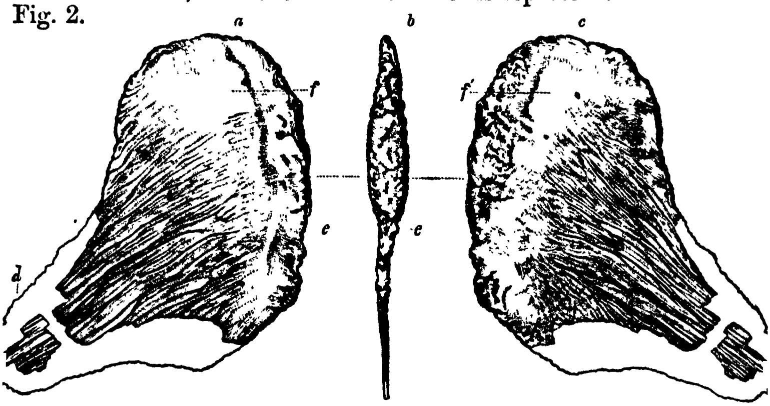


Fig. 3.—Dorsal plate of same individual; *a*, right side; *b*, thick basal margin; *c*, left side; other letters as in last figure.

All the figures are one-twelfth natural size.

The offensive weapons of this group were a series of huge spines arranged in pairs along the top of the distal portion of the tail, which was elongate and flexible, thus giving effective service to the spines, as in the genus *Myliobatis*.

In *Stegosaurus ungulatus*, there were four pairs of these spines, diminishing in size backward. Two of the larger of these are

shown on Pl. II. Figs. 2 and 3. In some other forms there were three pairs, and in *S. stenops* but two pairs have, as yet, been found.

In one large species, *Stegosaurus sulcatus*, there is at present evidence of only one pair of spines. These are the most massive of any yet found, and have two deep grooves on the inner face, which distinguish them at once from all others known. One of these grooved spines is represented on Pl. II. Figs. 4, 5, and 6.

The position of these caudal spines with reference to the tail is indicated in the specimen figured on Pl. III., which shows the vertebræ, spines, and plate, as found.

The American genera of the *Stegosauria* now known are *Stegosaurus*, *Hypsirhophus* and *Diracodon*. Of the former there are several well-marked species besides *S. armatus*, the type. Of the latter genus but one is known at present, *Diracodon laticeps*, the remains of which have hitherto been found in Wyoming at a single locality only, where several individuals referred to this species have been discovered. Aside from the form of the skull, these specimens have in the fore foot the intermedian and ulnar bones separate, while in *Stegosaurus* these carpals are firmly coössified.

All the known American forms appear to have the second row of carpals unossified, and five digits in the manus. In the hind foot, the astragalus is always coössified with the tibia, even in very young specimens, while the calcaneum is sometimes free. The second row of tarsals is not ossified in any of the known specimens. Only four digits in the hind foot are known with certainty, and one of these is quite small. All forms have at least three well-developed metatarsals, which are short and massive, but longer and much larger than the metacarpals. Most of the bones originally referred to the hind foot of *Stegosaurus ungulatus*, and figured as such (Amer. Journ. Sci. vol. xxi. pl. viii.), although found with the posterior extremities, subsequently proved to belong to the fore foot of another larger species.

In one large specimen, of which the posterior half of the skeleton was secured, no trace of dermal armour of any kind was found. If present during life, as indicated by the massive spines of the vertebræ, it is difficult to account for its absence when the remains were found, unless, indeed, the dermal covering had been removed after the death of the animal, and previous to the entombment of the skeleton where found. In this animal, the ilia were firmly coössified with the sacrum, thus forming a strong bony roof over the pelvic region, as in birds.

This specimen represents a distinct species, which the writer has named *Stegosaurus duplex*. It was originally referred by him to *S. ungulatus*, and the pelvic arch was figured under that name.[1] In the sacrum of this species, each vertebra supports its own transverse process, as in the *Sauropoda*, while in *S. ungulatus* these processes have shifted somewhat forward, so that they touch, also, the vertebræ in front, thus showing an approach to some of the *Ornithopoda*.

The great weight of the armour in *Stegosaurus*, taken in connection

[1] Amer. Journ. Sci. vol. xxi. pl. vii. Feb. 1881.

with the massive and solid bones of the skeleton, and, especially, the enormous vertical extent of the compressed tail, indicate an aquatic life. This opinion was expressed by the writer in describing the first specimen found, and the discoveries since made have done much to confirm it. That these reptiles moved freely on land, also, is quite probable. Other genera of the group may have lived mainly upon the land.

The large number of specimens of the *Stegosauria* now known from the American Jurassic, and the fine preservation of some of the remains, enable us to form a more accurate estimate of the relations of the group to the other Dinosaurs, than has hitherto been possible. The presence of a predentary bone, and the well-developed postpubis, are important characters that point to the *Ornithopoda* as near allies, with a common ancestry. These positive characters are supplemented by some points in the structure of the skull, and the form of the teeth.

There are, however, a large number of characters in which the *Stegosauria* differ from the *Ornithopoda*, and among these are the following:—

(1) All the bones of the skeleton are solid.
(2) The vertebræ are all biconcave.
(3) All the known forms have a strong dermal armour.
(4) The second row of carpals and tarsals are unossified.
(5) The astragalus is coössified with the tibia.
(6) The spinal cord was greatly enlarged in the sacral region.

The relations of these two groups to each other and to the rest of the known *Dinosauria* will be fully discussed by the writer in his monograph on the *Stegosauria*.

NEW HAVEN, CONN., *October*, 1887.

III.—ON CERTAIN ANOMALOUS ORGANISMS WHICH ARE CONCERNED IN THE FORMATION OF SOME OF THE PALÆOZOIC LIMESTONES.

By H. ALLEYNE NICHOLSON, M.D., D.Sc., F.G.S.,
Regius Professor of Natural History in the University of Aberdeen.

THAT many of the Palæozoic limestones are more or less extensively composed of the skeletons of various Invertebrate animals, sometimes in a perfect condition, sometimes more or less largely fragmentary, has long been known. In certain instances a microscopic investigation of these ancient calcareous sediments may fail to demonstrate the presence of organic remains, or may reveal but few of these. Thus there occur beds of lithographic limestone in the Palæozoic series which would seem to be simply of the nature of very finely levigated calcareous mud, the component grains of which were, however, doubtless derived, in the first instance, from the calcareous skeletons of animals. Again, it commonly happens, even in examples where the rock may to all appearance be little altered, that a limestone may be found on examination by means of thin sections to have undergone secondary crystallization, with the result of a more or less complete obliteration of the organic remains

of which it was originally made up. Such secondary crystallization is generally the result either of the application to the rock of pressure, or of dolomitisation. In the great majority of the ordinary Palæozoic limestones, it is, however, generally easy to show that the rock is essentially organic, in the sense that it is extensively or essentially composed of the calcareous skeletons of living beings. The organisms which are principally concerned in the formation of the Palæozoic limestones are, as is well known, the Crinoids, the Foraminifera, the Stromatoporoids, and the Corals. Less important, though nevertheless sometimes taking a conspicuous part in the composition of the older limestones, are the Brachiopods, the *Polyzoa*, various groups of Molluscs, and the Ostracodous Crustaceans.

In the present communication I wish to direct attention more particularly to some organisms which are largely concerned in building up certain of the Palæozoic limestones, but which cannot at present be definitely referred to a place in any of the groups of animals above mentioned. The organisms in question are curiously like one another in general form and mode of occurrence, at the same time that they differ entirely in their internal structure; and they have been referred to the anomalous genera *Mitcheldeania*, Wethered, *Solenopora*, Dyb., and *Girvanella*, Nich. and Eth., jun.

Genus Mitcheldeania, Wethered, 1886.

The organisms which compose the genus *Mitcheldeania* have the form of small rounded or oval calcareous masses, made up of capillary tubes, of an oval or circular shape, which radiate from a central point or points. and are intermixed with an interstitial tissue of very much more minute branching tubuli (Fig. 1). The larger tubes may be considered as zoöidal tubes, and the proportion which they bear to the interstitial tubuli varies in different specimens, and in different parts of the same specimen. Usually, the zoöidal tubes occupy comparatively extensive regions of the skeleton, being separated from one another by a limited number of the minute tubuli; the latter also occupying irregular tracts to the exclusion of the large tubes (Fig. 1, A and C). The zoöidal tubes further communicate with one another by means of large irregularly-placed foramina, resembling the "mural pores" of the *Favositidæ* (Fig. 1, G); and they occasionally exhibit a few irregular transverse partitions or "tabulæ." Increase appears to be by fission. The interstitial tubuli communicate with one another by irregular pores in their walls, or by branching, and they constitute a sort of "cœnenchyma," in many respects resembling the cœnosarcal tissue of *Allopora* (see Fig. 1, C).

The genus *Mitcheldeania* was founded by Mr. Wethered (Geol. Mag. 1886, Dec. III. Vol. III. p. 535) for the reception of certain singular little bodies which occur abundantly in parts of the Carboniferous Limestone of the Forest of Dean. The single species recognized was described by Mr. Wethered under the name of *M. Nicholsoni*,[1] and the author was good enough to submit some of his

[1] Mr. Wethered re-described and re-figured the species in the 'Proceedings of the Cotteswold Club,' 1887.

material to me for examination, thus enabling me to prepare for myself a series of thin sections. Owing, however, to its small size and to the minuteness of its component tissues, the investigation of *M. Nicholsoni* is attended with great difficulties; and I have been able recently to make a much more satisfactory study of the characters of the genus from a much larger species, which occurs abundantly in parts of the Carboniferous series of the South of Scotland, and which I shall describe under the name of *M. gregaria.*

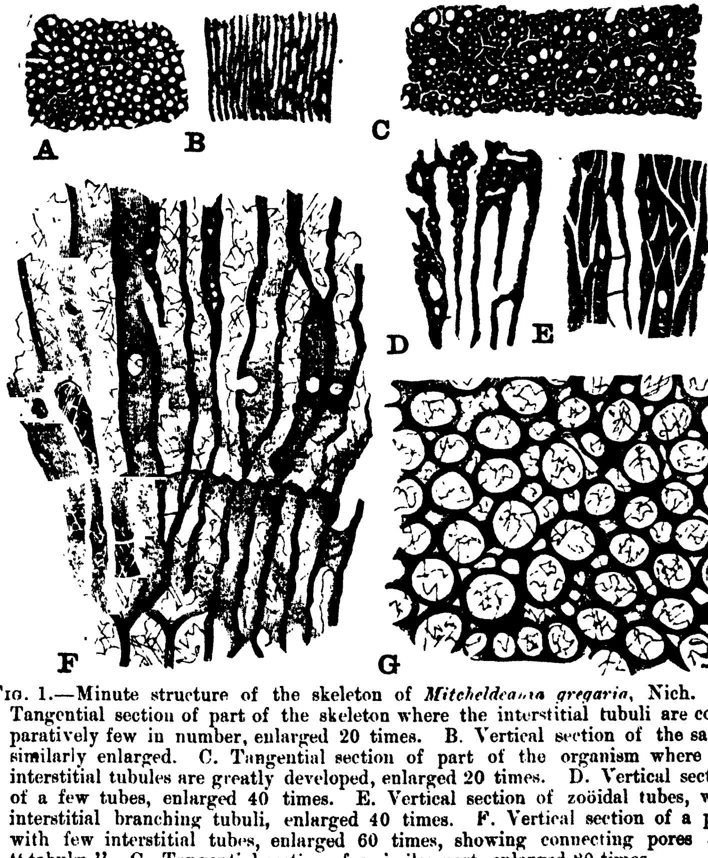


Fig. 1.—Minute structure of the skeleton of *Mitcheldeania gregaria*, Nich. A. Tangential section of part of the skeleton where the interstitial tubuli are comparatively few in number, enlarged 20 times. B. Vertical section of the same, similarly enlarged. C. Tangential section of part of the organism where the interstitial tubules are greatly developed, enlarged 20 times. D. Vertical section of a few tubes, enlarged 40 times. E. Vertical section of zoöidal tubes, with interstitial branching tubuli, enlarged 40 times. F. Vertical section of a part with few interstitial tubes, enlarged 60 times, showing connecting pores and "tabulæ." G. Tangential section of a similar part, enlarged 80 times.

Mitcheldeania gregaria, n. sp. Figs. 1 and 2.

The organism occurs in the form of small rounded masses, approximately spherical in shape, and averaging about 10 millimètres in diameter, some examples exceeding this, while others do not reach this size. There are no traces of a peduncle of attachment, nor do sections exhibit any foreign body which might have served as a nucleus of growth. The surface may be smooth, but is

in general more or less lobulated, exhibiting under a lens, in well-preserved specimens, exceedingly minute pores. The skeleton is composed of radiating capillary tubes, disposed in concentric strata, and having a diameter of from $\frac{1}{12}$ to $\frac{1}{15}$ of a millimètre. In large portions of the skeleton these zoöidal tubes are placed near to one another, being separated only by a single row of smaller tubuli (Fig. 1, F and G), or being in direct contact. In other portions of the skeleton, the large tubes may be absent or may be scattered irregularly among very minute tubuli. These interstitial tubuli (Fig. 1, A and C) have a diameter of $\frac{1}{25}$ of a millimètre, or less, and usually occupy irregular patches of various sizes, between the groups of larger tubes. Vertical sections show that the large zoöidal tubes communicate with one another by oval or circular apertures, of comparatively large size, and uniserially disposed, the general aspect of these resembling that of the "mural pores" of the *Favositidæ* (Fig. 1, F). Very commonly, indeed usually, the zoöidal tubes appear to be free from internal partitions, but transverse plates, resembling "tabulæ," can sometimes be recognized here and there. No structures of the nature of radiating "septa" are present in the tubes. The interstitial tubuli appear to communicate with one another by minute pores; and vertical sections show that they commonly branch irregularly, and anastomose with one another (Fig. 1, E). Hence, in tangential sections of the areas occupied by the tubuli, there are generally seen minute branching canals interspersed among the cut ends of the tubuli, and resembling in aspect the cœnosarcal canals of *Allopora* and *Millepora*, and of many Stromatoporoids (see Fig. 1, C).

This remarkable organism occurs in vast numbers in the Lower Carboniferous Series of parts of the South of Scotland and the North-west of Northumberland, and forms in places extensive beds of limestone. It was first brought under my notice by my friend Mr. Benjamin Peach, who informs me that it has a wide distribution; but the only locality in which I have personally collected it is

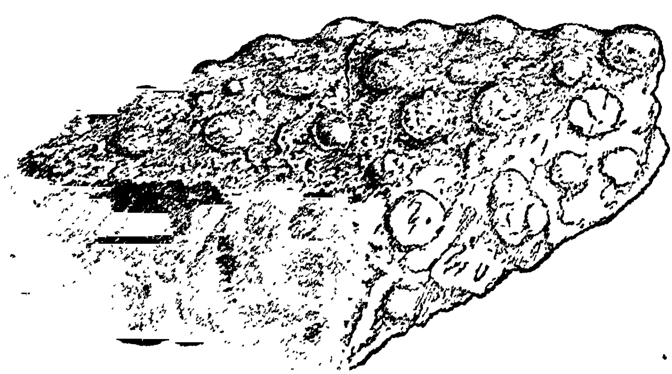


Fig. 2.—A fragment of limestone from the Lower Carboniferous Series of Kershope Foot, largely composed of *Mitcheldeania gregaria*, of the natural size.

Kershope Foot, in Roxburghshire. Here beds of the limestone are more or less extensively composed of the bullet-shaped or grape-like skeletons of this singular fossil (Fig. 2).

There is no room to doubt that *M. gregaria* is congeneric with *M. Nicholsoni*, Wethered, from the Carboniferous Limestone of the Forest of Dean. It is, however, clearly a distinct species, not only being constantly of much larger size, but being also distinguished by marked structural peculiarities. Thus, *M. Nicholsoni* rarely exceeds four or five millimètres in length, and is very irregular in form, commonly enveloping other organisms, or forming crusts on foreign bodies. The zoöidal tubes in this species are also proportionately large in point of size, are few in number and irregular in distribution, and are separated by a great proportionate abundance of minute interstitial tubuli.

Thin sections of *Mitcheldeania gregaria* have a general resemblance to corresponding sections of certain Monticuliporoids, but none of the latter make any approach to the present form as regards the minuteness of the component tubes of the skeleton. The presence of connecting-pores between adjacent zoöidal tubes and of an interstitial canal-system would also separate *Mitcheldeania* structurally from the Monticuliporoids. In spite of the extreme minuteness of its tissues, the genus *Mitcheldeania* may, I think, be referred with tolerable certainty to the *Cœlenterata*. Admitting its Cœlenterate affinities, it would seem almost certain that the genus must be placed in the series of the *Hydrozoa*. There is, however, no known group of this class within which *Mitcheldeania* can be satisfactorily located. Its closest affinities seem to be with the Hydrocorallines, and in this connection I would particularly draw attention to the resemblance of the interstitial tissue of *Mitcheldeania* to the cœnenchymal tissue of certain species of *Allopora*. In one species of the latter genus which I have investigated the cœnenchymal tissue is not only very similar to that of *Mitcheldeania*, but is not so very much grosser in structure. On the other hand, all the known Hydrocorallines possess zoöidal tubes which are enormously larger than those of *Mitcheldeania*; and there are other morphological features in the latter genus which would preclude its being actually placed, with our present knowledge, in the group of the *Hydrocorallinæ*.

Genus Solenopora, Dybowski, 1877.

This genus includes calcareous organisms, which present themselves in masses of varying form and irregular shape, and are composed wholly of radiating capillary tubes arranged in concentric strata. The tubes are in direct contact, and no "cœnenchyma," or interstitial tissue, is present. The tubes are thin-walled, irregular in form, often with undulated or wrinkled walls, without mural pores, and furnished with more or fewer transverse partitions or "tabulæ." No radiating "septa" are developed, but the type-species exhibits more or fewer inwardly directed septiform processes, which are the result of the rapid fission of the tubes (see Fig. 3, C).

The genus *Solenopora* was originally described by Dr. Dybowski (Chætetiden der Ost-Baltischen Silur-Formation, p. 124, 1877) for the reception of a singular fossil which is of common occurrence in the Ordovician limestones of certain localities in Esthonia. The structure of this organism has been fully dealt with by Mr. R. Etheridge, jun., and myself (GEOL. MAG. Dec. III. Vol. II. p. 529, Pl. XIII.), and we have shown its identity with the forms previously described by Mr. Billings as *Stromatopora compacta*, and by ourselves as *Tetradium Peachii*. The species stands, therefore, now as *Solenopora compacta*, Billings, the Scotch examples remaining as a variety, for which the name *Peachii* may be employed.

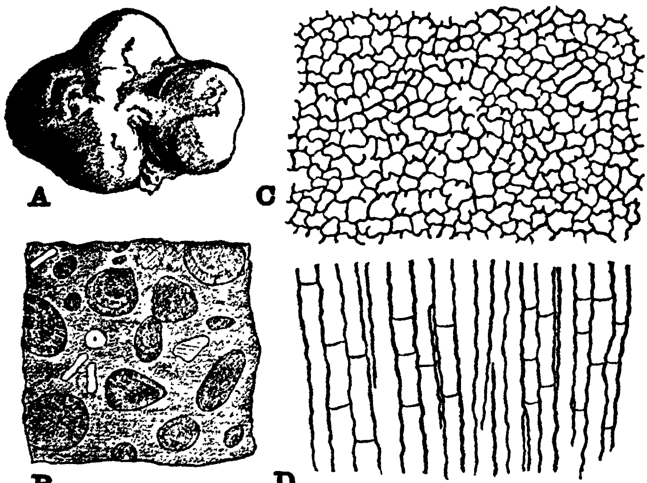


FIG. 3.—A, A small specimen of *Solenopora compacta*, Billings, from Saak, Esthonia, of the natural size. B, Surface of a piece of limestone largely made up of small specimens of the same, from the same locality, of the natural size. C, Tangential section of the same, enlarged about 35 times. D, Vertical section of the same, similarly enlarged.

SOLENOPORA COMPACTA, Billings, sp. Fig. 3.

This species has been so fully treated previously (*loc. cit. supra*), that it is unnecessary for me to enter here into any discussion of its characters. The accompanying illustration (Fig. 3) will sufficiently indicate its general form, mode of occurrence, and minute structure. As a species it is distinguished by the size of its component tubes (which vary in diameter from $\frac{1}{12}$ to $\frac{1}{20}$ of a millimètre), and by the facts that the tubes are irregular in shape, have undulated walls, and are furnished with more or less numerous septiform processes due to fission (Fig. 3, C and D).

It has been already shown by Mr. R. Etheridge, jun., and myself (*loc. cit.*), that *Solenopora compacta*, Billings, is very widely distributed in the Ordovician rocks, and that it played a very important part in the formation of certain of the limestones of this period.

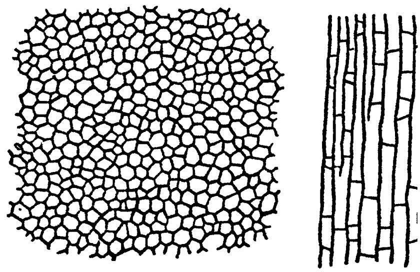
We recognized its occurrence in the Trenton and Black River Limestones of North America, in limestones of corresponding age in Esthonia ("Jewesche Schichten"), and in the Ordovician limestone of Craighead, near Girvan, in Ayrshire. To the facts previously recorded with regard to the range of this remarkable fossil, I can now add some further information of interest. Thus my friend Prof. Lapworth has recently submitted to me a number of examples of this species, of unusually large size, which he has collected in the "Hoar-Edge Limestone" of Shropshire. This discovery has the effect of extending the known range of *Solenopora compacta* in Britain from the Ordovician area of Ayrshire to that of the classical district of the West of England. Again, I find that the fossils described by Mr. S. A. Miller, from the Cincinnati group of North America under the name of *Stromatocerium richmondense* (Journ. Cincinnati Soc. Nat. Hist. vol. v.) are in part referable to *Solenopora*, and are undistinguishable from *S. compacta*, Bill., sp. Mr. E. O. Ulrich has been kind enough to furnish me with a number of specimens from the Cincinnati group of Indiana, which he regards as referable to the so-called *Stromatocerium richmondense*. These specimens are in the form of small irregular calcareous masses, very closely resembling one another in general appearance, but differing so far that, when broken across, some show a conspicuous composition out of concentric layers, while others are more compact and uniform in texture. In point of fact, the specimens, in spite of their apparent similarity, are not all the same. Some of them are referable to *Solenopora compacta*, Bill.; others are referable to a species of *Girvanella* (= *Strephochetus*, H. M. Seeley); while others are composed of both these organisms growing in superimposed colonies.

SOLENOPORA? FILIFORMIS, n. sp. Fig. 4.

In the Ordovician limestone of Craighead, near Girvan, there occurs a fossil which I may provisionally describe under the above name, and which is associated with the preceding in the formation of the limestone. It is often present in great abundance in the limestone, but its internal structure is commonly much obscured, or even destroyed by crystallization. It presents itself sometimes in the form of small rounded or irregular nodules, or, at other times, as lobate or ramified masses of considerable dimensions. Viewed with a powerful magnifying glass it appears to be quite compact, or obscurely fibrous; but when examined microscopically, it is seen to be composed of exceedingly minute capillary radiating tubes disposed in concentric strata. The tubes are thin-walled, regularly prismatic in shape, without mural pores or radiating septa, but furnished with numerous transverse partitions or "tabulæ" (Fig. 4). The average diameter of the tubes is about $\frac{1}{24}$ of a millimètre. Increase of the tubes appears to take place by fission, but the tubes do not exhibit inward septiform processes, such as are so characteristic of the cross-sections of the tubes of *Solenopora compacta*.

I have some doubts about the reference of this fossil to the genus

Solenopora, as it differs from the type of the genus in important structural characters. This is more particularly seen in the regularly prismatic form of the component tubes of the skeleton, and in the total absence of the septa-like process produced in *Solenopora compacta* by the commencing fission of the tubes. At the same time, it agrees entirely with *S. compacta* in its general form and mode of occurrence, and especially in its being composed of imperforate, tabulate tubes of excessive minuteness. Upon the whole, therefore, it seems safest to place it temporarily in the genus *Solenopora.*



A B

FIG. 4.—A, Tangential section of *Solenopora ? filiformis*, Nich., from the Ordovician limestone of Craighead, Girvan, enlarged about 60 times. B, Vertical section of the same, similarly enlarged.

It cannot be said that the present species throws much fresh light upon the systematic position of the genus *Solenopora.* If viewed without reference to the *size* of its tubes, it might quite well be regarded as a *Monticuliporoid*, and might be placed under the genus *Monotrypa.* The extraordinary minuteness of the tubes would seem, however, of itself, sufficient to preclude a reference of this fossil to the Monticuliporoids. If, however, we admit that the genus *Mitcheldeania* may be referred to the *Hydrozoa*, we can get over one of the principal difficulties attending the supposition that the genus *Solenopora* is referable to the same great class—the difficulty, namely, that no known Cœlenterate possesses a skeleton of such an excessively minute character. Upon the whole, therefore, I am inclined to think it may be tolerably safe to regard *Solenopora*, Dyb., as representing a peculiar extinct group of *Hydrozoa*, though I do not think that the evidence upon this point is in any way conclusive.

Genus GIRVANELLA, Nicholson and Etheridge, Jun., 1880. Fig 5.

Largely concerned in the formation of the Ordovician limestones of Ayrshire, and commonly associated with the preceding, is another remarkable organism which was described in 1880 by Mr. R. Etheridge, jun., and myself, under the new generic and specific name of *Girvanella problematica* (Mon. Sil. Foss. Girvan, p. 23, pl. ix. fig. 24). This curious fossil occurs in great numbers in the limestone at Craighead, sometimes being the principal agent in the formation of the rock, and presents itself in the form of small

rounded or irregular nodules, which vary in diameter from less than a millimètre to more than a centimètre. The larger examples (Fig. 5, A) show a distinctly concentric structure, visible even to the naked eye, but the most powerful lens fails to show any obvious internal structure in fractured or weathered surfaces. Examined microscopically by means of thin sections, the nodules of *Girvanella* are seen to consist of exceedingly minute circular tubes, endlessly contorted and bent, and twisted together in loosely reticulate or vermiculate aggregations (Fig 5, B). The tubes vary in their size from $\frac{1}{25}$ to $\frac{1}{60}$ of a millimètre in diameter. Most commonly they are about $\frac{1}{45}$ mill. in diameter. The walls of the tubes have a granular aspect, as if formed of exceedingly minute granules, but it is not possible to determine absolutely whether they are or are not truly calcareous in composition. No internal partitions are visible in the tubes, nor do they exhibit any perforations in their walls.

A B

Fig. 5.—A, Fragment of limestone from the Ordovician rocks of Craighead, Girvan, of the natural size, showing numerous exceptionally large masses of *Girvanella problematica*, Nich. & Eth. jun. B, Section of a minute mass of *Girvanella*, enlarged about 60 times.

In the original description of *Girvanella problematica* by Mr. R. Etheridge, Jun., and myself (*loc. cit.*), the genus was provisionally referred to the *Rhizopoda*, and was regarded as related to the arenaceous *Foraminifera*. This view of the affinities of *Girvanella*, from which I see no reason to depart, was the one taken by Mr. H. B. Brady, to whom we had submitted our specimens; and this distinguished authority compared *Girvanella* with the recent *Hyperammina vagans*, figures and descriptions of which have now been published (see Chall. Reports, vol. ix. p. 260, pl. xxiv. figs. 1–9). The same author's great work on *Foraminifera* contains, however, another genus of arenaceous *Foraminifera* which admits, perhaps, of an even closer comparison with *Girvanella* than does the form above mentioned. I allude to the remarkable form described by Mr. Brady under the name of *Syringammina fragilissima* (Chall. Reports, vol. ix. p. 242, woodcut), in which the organism is free, and consists of a mass of minute arenaceous tubes disposed in concentric layers, and having a generally radiate arrangement.

In Britain, the genus *Girvanella* has, so far, only been recognized as occurring in the Ordovician limestones of Ayrshire. I have, however, found some of the Carboniferous limestones of the North of England to contain largely an ill-preserved organism which will, I think, prove to be referable to *Girvanella*. As previously pointed out, the genus occurs in the Ordovician rocks of North America. This is shown by the fact that certain of the specimens from the Cincinnati Group of Indiana sent to me by Mr. E. O. Ulrich as belonging to the *Stromatocerium richmondense* of Mr. S. A. Miller, prove on examination to belong to a species of *Girvanella*, specifically distinct, I think, from our British species, as shown by the greater minuteness of its tubes. I see, also, no reason to doubt that the fossils from the Chazy Limestone of North America, for which Prof. Henry M. Seeley has proposed (Amer. Journ. Sci. and Arts, 1885, vol. xxx. p. 355, 1885) the new generic name of *Strephochetus*, are in reality referable to the genus *Girvanella*. It is probable that the Chazy form (*Strephochetus ocellatus*, Seeley) is *specifically* distinct from *Girvanella problematica*, but its *generic* identity appears to be indubitable.[1] Prof. Seeley seems disposed to think that the curious fossil described by Prof. James Hall, from the Calciferous Limestone, under the name of *Cryptozoön proliferum* (Thirty-sixth Ann. Rep. of the State Cabinet, pl. vi. 1884), may be related to *Girvanella*; but I cannot think that such a relationship—supposing it to exist—can be one of generic affinity. The fossil for which Prof. Hall has proposed this name is not only comparatively gigantic in point of size, but its internal structure, so far as may be judged from the incomplete provisional diagnosis given by its author, is altogether different, since it is stated to consist of branching and anastomosing canaliculi. Lastly, with regard to Prof. H. M. Seeley's reference of *Girvanella* (=*Strephochetus*) to the calcareous sponges, it need only be said that the structure of the genus, so far as recognized, shows nothing which would warrant such a reference, and that it would be essential to the establishment of this view, according to our modern lights, that the organism should be proved to possess definite spicules.

IV.—Hertfordshire Subsidences.

By A. C. G. Cameron.

SUBSIDENCES are by no means unusual amongst the arable lands in the Chalk districts of this county. No one, who has travelled in these parts, can have failed to notice the numerous holes and dells dotted about the fields in all directions, many of which have fallen in, or will do so, in course of time. Nearly all of them mark spots where the Chalk has been dug up for chalking the land, which is then said to work better.[2]

On the crown of some hill or ridge, it is no uncommon sight to

[1] Dr. Hinde has already pointed out that *Strephochetus*, H. M. Seeley, is identical with the previously described *Girvanella*, and has further shown that the *Siphonema* of Dr. Bornemann, supposed by its describer to be a calcareous Alga, is likewise a synonym of *Girvanella* (Geol. Mag. 1887, Dec. III. Vol. IV. p. 227).

[2] Gravel soils, such as fringe the modern alluvium of rivers and streams, are chalked as well as the stronger soils.

find a windlass and bucket erected over a circular hole or shaft sunk deep in the Chalk, while a man at the bottom, working right and left of him, sends bucketfuls of dazzling, white chalk to the surface, which is wheeled away in barrows, and deposited in heaps close to one another, in the field where the shaft has been sunk, to be afterwards broken up, and lain about the place.

When all the chalk that is required has been dug up, the windlass disappears, and the hole is filled up to the original surface level, in order that no unnecessary unevenness should occur to mar the ploughing. Gradually however, a subsidence takes place, as the material, with which the hole was filled, settles down in the cavity prepared for it, and then for a time, a basin-shaped hollow marks the site of the shaft. Suddenly a deep ring-like orifice, the sides of which show a clear section of the earth and stones, with which the hole was filled, appears at the bottom of the pit, and a veritable swallow-hole is formed on the spot.

If it is only a subsiding hole, that is, one that may go down at any moment, a short funnel or pipe is seen, without the ring-like orifice and clean cut sides.

Harvest is the time, I am told, when these pits most frequently fall in; but as the subsidences also occur during rainy seasons, when water wells up or accumulates at the bottom, I am inclined to think the reported falling in at harvest time is greatly accounted for by reason of more people being in the fields then to observe them than at any other time. Holes are being re-filled this autumn about here, that have required filling several times before.

In some parts of the county "doming" is resorted to for covering the holes, thereby obviating the periodical filling up, which may require doing yearly. A pit to be domed, is first nearly filled up to the original surface-level, at least presumably so—and then arched over with brickwork and covered with earth. This plan is said to cost no more than the other, but the latter is the safer of the two.

A labourer informed me that somewhere in the Baldock country, a domed hole once caved in when a ploughman and lad with three horses were crossing it. The two attendants had a narrow escape for their lives, the three horses were killed. Poles are sometimes put up to show the sites of these pits.

The foregoing brings to my recollection much that is in common with the 'natural pits' at Ripon,[1] where it will be remembered a haystack disappeared down a cavity[2] that suddenly opened in the limestone, during the time the haymakers had adjourned for dinner. Doubtless some Hertfordshire subsidences[3] are as natural as those at Ripon—due to the dissolution of the strata by acidulated waters.

Semicircular holes in the chalk filled with brickearth, often seen

[1] See Natural Pits at Ripon, by Rev. Stanley Tute, Proc. Yorks. Geol. and Polyt. Soc. 1869. Also 'Subsidences over Permian Limestone,' A. C. G. Cameron, Rep. Brit. Assoc. York, 1881, and Proc. Yorks. Geol. and Polyt. Soc. vol. vii. pt. iv.

[2] Locally named "shoots" and "earthquakes."

[3] See "Nature," vol. xxxvii. Dec. 8, 1887, On an Earthquake in England, by Worthington G. Smith.

where any considerable section of Chalk is exposed, as in a rail or road cutting, indicates natural subsidences whose origin may be traced to causes similar to those at Ripon.

If it were possible to see the surface of the Chalk, bared of its superficial covering of clay, loam, etc., it would, I imagine, be singularly convex and concave. In digging pits, the chalk is is sometimes found close to the surface at one side of the shaft, but cannot be found at twenty or even thirty feet on the other side.

V.—Effects of Alternations of Temperature on Terra Cotta Copings set in Cement as an Illustration of a Theory of Mountain Building.

T. Mellard Reade, C.E., F.G.S., F.R.I.B A.

ELSEWHERE I have shown that metals under certain conditions when subjected to changes of temperature undergo permanent deformation. Thus sheets of lead ridge up and fold even under the influence of atmospheric changes, as may be seen by the examination of any old lead flats or gutters. The cumulative effect of small but repeated changes of temperature is very striking, and I have used it in illustration of what I conceive to be the true explanation of the ridgings up of the earth's crust called mountain ranges. The examples given[1] of the effects of alternations of temperature are mostly in metals, but I have also shown that other materials not ductile are affected in the same way, in a lesser degree.

A very remarkable example has lately come under my notice[2] of the lengthening of a terra cotta coping, which it appears to me can only be explained on the same principle.

The coping in question which, is freely exposed to the direct rays of the sun, consists of two courses of red Ruabon terra cotta bricks set in cement upon a fence wall, built with common bricks in mortar a brick and a half thick. The courses are level, but, in consequence of the inclination of the road, the coping is stepped down at intervals, so that the under-course of bricks of one length is just gripped and held in position by the top course of the next length of coping. It will thus be seen that it must constitute by liability to lifting a more delicate test than ordinary of any increase of length that might take place in the coping.

When I examined the coping—and I have looked at it over and over again—the end portion of one length abutting against the next length at the drop in the level was thrown up into an anticlinal of about 6 ft. span; the coping bricks being lifted in the highest part one inch from their bed. There was a fracture at the crown of the anticlinal, and another at the foot or springing, but for a distance of 30 feet the coping was practically one solid continuous bar. A careful examination showed that the coping had "grown" about a quarter of an inch longer than when it was first set, and that this

[1] Origin of Mountain Ranges, chap. iii. and iv.

[2] I am indebted to Mr. F. Archer for first calling my attention to it.

lengthening, as shown by movement on the corbel bricks which occur at intervals, was evenly distributed along a length of 30 feet.

One of the first explanations that occurred to me was that the lengthening was due to the expansion of the cement, as we know that cement if used too soon does expand for a certain length of time after setting.[1] Enquiry from the builder, Mr. Bates, who put up the wall, showed this not to be a probable explanation, as the wall was built some seven years ago. Mr. Bates informed me that he reset the end bricks of this portion of the coping, about two years after the wall was built, in consequence of its lifting, and I have ascertained that Mr. Taylor, a bricklayer, has reset it on two occasions when it lifted from the same cause, first on May 9th, 1884, and secondly on May 16th, 1885. He has now just reset it for a third time.

An inspection of brick copings in the neighbourhood of Blundellsands, of which there are many, disclosed the fact that this is not a solitary phenomenon. In another case where the coping is of blue Staffordshire bricks, the top course in cement and the under-course in mortar, a change in length is shown clearly by the coping being lifted off the wall at each of the two ramps (curved changes of level) which exist in its length, and the movement can be clearly measured on the corbel bricks as before, and in this case the lengthening is also a quarter of an inch, evenly distributed over a considerable length of coping.

Numerous other examples are to be seen, which, though not so striking as those described, clearly evince a movement of the copings.

It will no doubt be considered a long step from brick copings to mountain-building, but as a good example of the permanent lengthening that may take place as the accumulated result of small movements of expansion by change of temperature in what appears to be an intractable material, the facts are well worthy of record. It appears that when the ends of a coping such as I have described butt up against a solid pier, this movement does not take place probably from the elasticity of the material being sufficient to absorb whatever small expansions may occur.[2] When one end is partially free to move, the effect is different, each expansion, however small, pushing the coping along towards the partially free end, and on contraction the coping cannot draw itself back to the same position as before, so must either fracture or lengthen by increments, and experience shows that is what frequently happens.

[1] In order to ascertain precisely whether any alteration of length does take place in cement, I had a bar made composed of one of best Portland cement to one of fine sand. In this bar were fixed brass studs for measuring purposes. On Sept. 1st, three weeks after it was made, the bar measured 16·136 inches between the studs On Nov. 6th it measured 16·122 inches, showing a *shrinkage* of 0·014 of an inch, and the contraction has not yet ceased.

[2] Since this was written I have observed several cases in which the end brickwork and piers have been badly fractured by the force of expansion.

VI.—British Upper Tertiary Corals.

By Alfred Bell.

WRITERS on Fossil Corals seem to ignore the existence of Corals in our later Tertiary formations. They are certainly not common. The following reference and species have come under my notice: *Caryophyllia clavus, Scacchi* var. *borealis*, Flem., Lancashire drift (see Geologist, 1843, p. 124). *Caryophyllia clavus* var. *Smithii*, Stokes, Raised beach, Portrush, Co. Antrim (Portlock, Geol. Londonderry, etc.). *Sphenotrochus Wrightii*, Gosse, from the Clyde beds, by Messrs. Crosskey and Robertson. To these I may add a fine calice of the Norway branching Coral *Lophohelia prolifera*, Ed. and H., from the interglacial sands of King Edward, N.B., and a single young example of *Sphenotrochus Macandrewanus*, E. and H., from the Raised sea-bed, Largo Bay, Fife.

Two species occurring in the disturbed portion of the Suffolk Red Crag appear to be of Diestien origin, viz. *Solenastrea Prestwichii*, Dunc., present in beds of that age in Belgium (Brussels Museum), and a stout form of *Flabellum*, whose affinities are rather to *F. appendiculatus*, Nyst, than to *F. Woodii* of the Coralline Crag, to which it is commonly referred. I judge this after an examination of a large number of specimens of the different species—mostly worn and rolled examples.

The "Reed Coll.," York Museum, contains a minute *Sphenotrochus* not more than $\frac{1}{16}$ inch in height, which I obtained from the well-known Chillesford Sands at Aldeby. I have only seen this one example, and have, pending further discoveries, given it the trivial name of *S. parva*.

The Crag *Sphenotrochi* would probably repay further examination, as in several instances I have noticed that the costæ instead of presenting the usual strait parallel arrangement, sometimes wavy at the lower end, are strongly wavy, the projections interlocking one within the other

P.S.—Since writing the above Mr. Tomes, F.G.S., has kindly examined the corals referred to in the last paragraph, and describes them as follows:—

Sphenotrochus Boytonensis, Tomes, n.s.

The corallum is of equal breadth for the whole of its height, but it is very thin at the base. The curve of the margin of the calice in the long direction is about the same as in *Sphenotrochus intermedius*. The long diameter of the calice to the short one is as 6 to 4. There are twenty-four septa and the primary and secondary ones are united to the columella by trabiculæ, which are not in pairs, but are single. A few large papillæ appear on the sides of the septa, which have also horizontal ridges ending in simple blunt teeth on their inner margin. These with the growth of the corallum are elongated inwards and become trabiculæ, and are attached to the columella. The latter part as in *Sphenotrochus intermedius* is notched in the middle. The costæ are very uniform in size over the whole of the

corallum, and they are all strongly crispate[1] on every part of it. Height of the corallum 7 lines; greater diameter of the calice, 3 lines, its smaller diameter 2 lines.

The greater size of this species, its remarkable costæ, and the ridges on the sides of the septa will distinguish it. In the nature of the costæ, though in no other respect, it bears some resemblance to *Sphenotrochus crispus*.

The ridges across the septa ending internally in trabiculæ are very peculiar, and give to the latter a greater degree of importance than they would otherwise have.

Localities.—Coralline Crag, Oxford; Red Crag, Boyton, Suffolk; Walton-on-the-Naze, Essex.

NOTICES OF MEMOIRS.

I.—On the Migrations of Pre-Glacial Man. By Henry Hicks, M.D., F.R.S., F.G.S.[2]

REFERRING to the further researches carried on, this summer, at Cae Gwyn Cave, North Wales, which is 400 feet above sea-level, the author stated that the additional evidence obtained proved most conclusively that the flint implement found there last year in association with the remains of Pleistocene animals was under entirely undisturbed Glacial deposits. He maintained also that the evidence is equally clear in regard to the implements found within the caverns, which he said must have been introduced before marine action disturbed the contents of the caverns and the Glacial deposits blocked up and covered them over. The question as to the direction from which pre-Glacial man reached this country is an exceedingly interesting one, and seems now to be fairly open to discussion. It is admitted to be fraught with difficulties, but the facts recently obtained seem to require that an attempt should be made to unravel it. The evidence, so far as it goes, points to a migration to this country from some northern source, as the human relics found in the caverns, and also in the older river gravels (which Prof. Prestwich is now disposed to assign also to the early part of the Glacial epoch, when the ice-sheet was advancing), occur in association with the remains of animals of northern origin, such as the Mammoth, Rhinoceros, and Reindeer. Up to the present no human relics have been found in this country (and it is very doubtful whether they have been found in any other part of Europe) in deposits older than those containing the remains of these northern animals. If man arrived in this country from some eastern area, it is but natural to think that he would have arrived when the genial Pliocene climate tempted numerous species of Deer of southern origin, and other animals suitable as food for man, to roam about in the South-east of England.

[1] I borrow this descriptive word from MM. Milne Edwards and Haime, but it would be almost better to say that they are zigzag or serpentine.

[2] Abstract of Paper read in the Anthropological Section of Brit. Assoc. Manchester.

Hitherto, however, not a relic has been found to show that man had arrived in this country at that time. But in the immediately succeeding period, with the advent of cold conditions and of the northern animals, evidences of his presence become abundant.

Whether man at an earlier period migrated northward from some tropical or sub-tropical area, where he could have lived on fruit and such like food, there is no evidence at present to show; but it seems certain that the man of the Glacial period in this country lived mainly on animal food, and that he found the Reindeer to be the most suitable to supply his wants. He followed the Reindeer in their compulsory migrations, during the gradually increasing Glacial conditions, and kept mainly with them near the edge of the advancing ice.

II.—On the Discovery of Carboniferous Fossils in a Conglomerate at Moughton Fell, near Settle, Yorkshire. By Robert Law, F.G.S., and James Horsfall.[1]

After briefly noting the various exposures of the conglomerate, its unconformability with the Silurian rocks, its nature, probable age, and the circumstances which led to the discovery of fossils in it; the authors described the following section exhibited on the south-west side of Moughton Fell.

a. Scar Limestone, of light grey colour and well jointed; layers very distinct in lower parts and almost horizontal, the genus *Bellerophon* being the commonest fossil in the lowest bed of this rock. Thickness from 300 to 500 feet.

b. Conglomerate.—Of a bluish-grey colour when newly fractured, and becoming reddish on exposure to the air. The fragments are rounded, angular, and sub-angular in form, consisting of slate, grit, flagstone, and vein-quartz, all apparently derived from Silurian rocks. Fossil shells and corals are common throughout the bed. *Bellerophon*, *Euomphalus*, *Syringopora* and *Lithostrotion* are the prevailing genera. Thickness from 1 to 12 feet.

c. Lower Silurian slates, of great thickness, having a N.E. strike and a dip of about 65°. The dip and cleavage appear to be on the same plane in this locality.

The nature and the origin of the stones in the conglomerate were next pointed out; also it was shown that the portion of the bed in which fossils had been found was not more than 200 yards in length, and that it was thickest in the middle, thinning out to the east and west, and at one point could be seen merging into the overlying limestone.

The fossils collected from the conglomerate are as follows:—

Syringopora ramulosa.	*Bellerophon cornu-arietis.*
Lithostrotion basaltiforme.	*Natica plicistria.*
Euomphalus pentangulatus.	*Natica lirata.*
Cirrus, one species.	*Natica elliptica.*
Sanguinolaria angustata.	*Inoceramus*, one species.
Pleurotomaria, one species.	*Spirifera*, one species.
Orthoceratite, one species.	*Pecten*, one species.
Rhynchonella acuminata.	*Productus*, three species.
Bellerophon tangentialis.	*Leptæna*, one species.

In conclusion, attention was called to the probable method by which the conglomerate was formed.

[1] Abstract of paper read before the Geological Section of British Association, Manchester, 1887.

REVIEWS.

I.—MEMOIRS OF THE GEOLOGICAL SURVEY. ENGLAND AND WALES. THE GEOLOGY OF PART OF EAST LINCOLNSHIRE. By A. J. JUKES-BROWNE, F.G.S. 8vo. pp. 181, with 25 Woodcuts and a Plate of Sections and Map. (London, 1887.)

THIS memoir treats of the geology of the country near the towns of Louth, Alford, and Spilsby, and is the official Explanation of Sheet No. 84 of the Geological Survey Map of Great Britain. In a concise introductory note the Director-General tells us that the district of which the geology is here described is the southern half of the Wolds, north of the Wash; and that the Memoir gives (1), a detailed account of the various Formations from the Kimeridge Clay to the top of the Middle Chalk. (2.) The subdivisions established by Professor Judd among the Lower Cretaceous (Neocomian) rocks of Lincolnshire have been adopted by the Geological Survey, as well as his name of "Tealby Beds" for the Middle Division of that series. The name of "Spilsby Sandstone" is proposed for the Lower Division. The Upper Group, or "Carstone," here generally consists of mere loose sand. The several subdivisions of the Chalk in this region are now for the first time compared with those which have been worked out by the Survey in Buckinghamshire and Cambridgeshire. (3). A full description is likewise given of the Glacial Deposits which occupy the lower grounds flanking the Wolds; but for his theoretical views, which are not always in accord with those of his colleagues, the author of the Memoir is himself responsible. In connexion with the superficial deposits, he has discussed the comparative age of the several valley-systems of the district. (4). Among the facts of economic importance described in the Memoir is the discovery of two horizons of ironstone and also a seam of phosphatic nodules. (5). A large number of well-sections bearing on the subject of Water-supply are given in the Appendix.

A general description of the geological structure and the physical characters of the district is first given, with lists of the heights, and some sections (pp. 1–8). The Kimeridge Clay is then described (pp. 9–12). The so-called Neocomian Series (pp. 13–27) begins with a nodule-bed on the Kimeridge Clay and at the base of the Spilsby Sandstones, which latter alone the author refers to the *Neocomian* of the Continent, whilst others make it the lower part of that series. The nodules consist largely of rolled fossils, difficult to determine, but for the most part derived from older beds, probably Kimeridgian (p. 18), but possibly Neocomian (p. 139).

The sandstone has large calcareous, fossiliferous concretions in it; and the fossils comprise both Oolitic and Neocomian forms, indicating an intermediate stage between the two systems (p. 141).

Then follows the variable Hundleby Ironstone, equivalent to that at Claxby, and forming the base of the Tealby Clay. This ironstone is a ferruginous loam with oolitic grains of iron-oxide; and the facies of its fossils "is characteristically Neocomian" (p. 141).

The "Tealby Beds" are (1) the ironstone above mentioned; (2)

clays with thin sandstones, septarian nodules, selenite, and pyrites; (3) the "roach," a ferruginous marl with oolitic grains. The clays and the nodules near their base give fossils of an "eminently Neocomian" character. The sands representing the "Carstone," or Upper Neocomian of the district (pp. 23–27), have few fossils, but many phosphatic nodules.

The Upper Cretaceous of Lincolnshire (pp. 28–70) consists of the Lower Chalk and the Middle Chalk; and this begins with (1) the Red Chalk (overlying the Carstone Sands); and this is succeeded by (2) the "Inoceramus-beds," (3) the "zone of *Holaster subglobosus*," and (4) a "shaly marl." Next above comes (5) "hard rocky chalk," making the base of the Middle Chalk, followed by (6) "Chalk with flints and *Inoceramus Brongniarti*." In Cambridgeshire the equivalents of these divisions are—for part of 1, 2, and part of 3, the "Chalk-marl," or "zone of *Rhynchonella Martini*"; for part of 3, the "Totternhoe Stone"; for the rest of 3 and 4, a similar zone and shaly marl; for 5, the "Melbourn Rock" and the "zone of *Rhynchonella Cuvieri*"; for 6, the "zone of *Terebratulina gracilis*," which is succeeded by the "zone of *Holaster planus*," and then by the "Chalk-rock," neither of which members of the Middle Chalk appear in Lincolnshire (p. 30 and footnote). The relative value of these divisions is discussed; the details of their thicknesses, characteristics, and chemical constitution, and palæontology are carefully explained, as well as their sections, exposures, and surface-features. Six woodcuts and several tables illustrate this chapter; and the fossils are tabulated and noted at pp. 142–147.

The Glacial Deposits (pp. 71–101, with woodcut sections, figs. 11 to 19) are described in detail as the "Older" and the "Newer Boulder-clay;" and the Post-glacial Deposits (pp. 102–112), as (1) the "Revesby Gravel"; (2) the Marsh and Fen Deposits; and (3) Blown sand. All of much interest, both locally and generally.

Chapter IX. (pp. 113–131), treating of the hills and valleys of the Wolds, is an explanation of the physical features of East Lincolnshire, worked out *con amore*, carefully written, and well illustrated with plans and sections. Amateurs as well as specialists must derive a real scientific pleasure in following Nature's progressive handiwork in rendering this part of the East of England what it now is.

The *Economics* and *Water-supply* are very well calculated to serve the country. A useful Index and good plate of sections complete this valuable Memoir.

II.—Die Bryozoen der weissen Schreibkreide der Insel Rügen von Th. Marsson. Mit 10 Tafeln. Band 4, Heft 1, 1887. 4to. pp. 1–112. Palæontol. Abhandl. herausgegeben von Dames und Kayser.

TO Dr. Marsson of Greifswald palæontologists are already indebted for two beautifully illustrated memoirs on the Foraminifera,[1] Cirripedia and Ostracoda of the White or Upper

[1] Mittheil. des naturwiss. Ver. für Neuvorpommern u. Rügen in Greifswald. Zehnter Jahrgang, 1878, pp. 115–196, Taf. I.–V.

Chalk of the Island of Rugen;[1] in the present memoir the Bryozoa of the same formation and locality are described in a similar careful and complete manner, and the new forms, as well as those imperfectly known before, are faithfully represented in the accompanying ten plates, drawn from nature by the author's hand. This group of organisms was included with others from Rugen in a memoir by von Hagenau[2] nearly fifty years since, but this author freely acknowledged the imperfect character of his work, which, however, he did not live to amend and complete. Dr. Marsson enumerates in the present memoir no fewer than 229 species, of which 84 belong to the Cyclostomata and 145 to the Cheilostomata. The following new genera are constituted, *Cryptoglena, Epidictyon, Cavarinella, Rhipidopora, Clinopora, Crisidmonea, Stigmatocatros, Phormopora, Phormonotos, Phyllofrancia, Pithocella, Solenophragma, Bactrellaria, Coscinopleura, Columnotheca, Tænioporina, Bathystoma, Systenostoma, Platyglena, Nephropora, Lekythoglena, Homalostega, Balantiostoma, Cryptostoma, Dioptropora, Kelestoma, Lagodiopsis, Prosoporella, Pachydera*, and *Stichocados*. Of the species enumerated 117 are peculiar to Rugen, and 96 of these are new forms, but it is probable that many of them will be subsequently discovered in other localities. It is certain, however, that a great many are limited to the Rugen Chalk, and no traces of them appear in the same formation of England or France. Four species extend down to the Neocomian, one to the Gault, 21 to the Cenomanian, and nine to the Turonian. With the Chalk of Maestricht there are 45 species in common. Only five species reach upwards to Tertiary strata, and one of these, *Entalophora virgula*, v. Hag., has survived to the present time, Mr. Waters stating that he can discover no differences between the fossil and existing forms.

G. J. H.

III.—Geologie von Bayern. Von Dr. R. Wilhelm von Gümbel. Erster Theil: Grundzüge der Geologie. Lieferungen 1–5. Large 8vo. pp. 1087. (Kassel, 1884-7, Theodor Fischer; London, Williams and Norgate.)

WITH the lately-issued fifth part, the first volume of the 'Geology of Bavaria' is completed; it contains 1078 pages of printed matter and very numerous illustrations in the text; thus forming a massive volume. This first volume is entirely devoted to the "Grundzüge der Geologie," and it has no special bearing on the 'Geology of Bavaria,' which is reserved for the second volume. It forms a very comprehensive and complete Manual or Handbook to Science, and may fairly claim a position equal to that held by our English Text Book of Geology by Dr. Geikie, and by Lapparent's Traité de Géologie in France.

The subject is treated under three heads: (I.) Hylology of the Earth; (II.) Formation of the Earth, or Geotektoriek; and (III.) Geogeny, or the History of the Earth's Development. Under the

[1] id. 12 Jahrg. 1880, pp. 1–50, Taf. i-iii.
[2] Monogr. der Rügens'chen Kreide-Verst. 1839.

first heading is comprised a very full description of the mineralogical and petrographical constituents of the Earth's crust, and their microscopical characters are particularly well illustrated. This is followed by a section on the Morphology of the rocks and of the Crust of the Earth formed by them, and their origin and formation are treated in another section. A general review of the different organisms occurring as fossils is also included in the Hylology, and figures are given of the principal representatives of each group.

Under the second heading of the Formation of the Earth, the Archæolithic, Palæolithic, Mesolithic, Kænolithic, Post-tertiary and Novär or Recent Groups are described, and their mode of occurrence and development in different parts of the Earth are fully referred to. Figures are given of the most typical sections in various countries and of the leading fossils of each group.

In the third division of Geogeny or history of the Earth's development, the relations of the Earth to the universe and to the solar system are considered, as well as its individual character as a planetary body. In the concluding sentence of this division and of the book the author states, that if from a geological standpoint we may draw a conclusion as to the future of the Earth from its past history. we may look forward to an almost unending period, as measured by human standard, of still higher development, and in the furthest distance there is the probabality of a gradual and finally complete refrigeration and the exhaustion of its waters. G. J. H.

IV.—Les Eaux Souterraines à l'Epoque actuelle; leur régime, leur température, leur composition au point de vue du rôle qui leur revient dans l'économie de l'écorce terrestre. Par A. Daubrée, Membre de l'Institut, etc., etc. Two vols. pp. 757, with numerous illustrations. (Vve. Ch. Dunod, Éditeur, Paris, 1887.)

THIS important work bears about the same relation to "Les Eaux Souterraines aux Époques Anciennes," reviewed in our last Number, as the "Principles of Geology" does to the "Elements," inasmuch as it treats of causes now in operation. The author, from the position occupied by him, has had great opportunities for acquiring information on this most extensive subject from all quarters of the world. and the work consequently is the result, in part, of his own large experiences, and partly a selection from the information afforded by other writers.

The first book, which is also the largest and most important, contains seven chapters devoted to the consideration of the phenomena in connection with the system (régime) of underground waters. He commences with an allusion to quarry-water, giving an extract from the results of M. Delesse of the weight of quarry-water per hundred of the wet mass, ranging from 20·66 in white chalk to 0·08 in vein-quartz. In a previous review of Mons. Daubrée's great work (Études synthétiques de Géologie expérimentale) mention was made of the important part which this same quarry-water plays in the economy of the Earth's crust, and of the interesting experiments

of the author by way of showing how it can make its way against a powerful pressure of steam. This has an important effect in the general mechanism of infiltration (vol. ii. p. 214), and helps to overcome the obvious difficulty with respect to water circulating in open fissures, which would appear liable to be forced back by pressure from within.

After giving a description of the permeable and impermeable rocks, the author discusses the phenomena in connection with the more superficial sheets of water, such as have no impermeable bed above them. Having rather a partiality for Greek compounds, he designates this "Phreatic Water." The water-line, or upper level of this sheet, ranges from a few feet to 100 mètres or more. This "Phreatic," or well-water, is largely distributed throughout Drift beds (Terrains de transport), and many plans and sections are given showing its "régime" in different towns of Europe. He quotes from Prestwich's address to the Geological Society (1872) with reference to the water-bearing gravels of London which repose on an impermeable clay, and relates how that, before the great water companies furnished an independent supply, the metropolitan population was largely confined to the water-bearing gravels. Curiously enough, in order to illustrate this, a section is given of the aquiferous gravels at Oxford resting on the Oxford Clay. Not the least interesting account of the superficial sheet of underground water is that relating to the Fontanili of Lombardy, illustrated as usual by small plans and sections. The inhabitants of the favoured district are in the habit of knocking out the bottom of a tall cask, and placing it in an aquiferous bed, some two or three mètres below the surface, when the pressure raises the water in the shaft or funnel thus formed, and a notch being cut in the upper rim, the surplus water is thus conducted into channels of irrigation, much on the principle of water meadows in the South of England. The water-bearing strata of Lombardy above referred to occur in the gravels and sands of old and modern alluvions, and the water which they contain percolates towards the great rivers to such an extent as to restore to these the water of which the numerous irrigation canals had deprived them.

The "Phreatic Water" is by no means confined to the Drift, as of course beds of Tertiary, Cretaceous, Jurassic age, etc., contribute their quota when these occupy the surface of a country. Under this heading some interesting details are given of the well-water of Paris, which, it appears, is contained partly in the alluvium and partly in permeable Tertiary beds upheld by the Plastic Clay. Since M. Daubrée has so extremely enriched his work with plans, sections, photographs, etc., a section across the valley of the Seine at Paris in illustration of these interesting details would have helped the reader, who is not a little puzzled to find a plan apparently of the alluvial deposits near Paris immediately under the heading "terrains tertiaires des départements de la Seine, etc."

The results of contact between permeable and impermeable rocks are next discussed. The contact may be the result of simple stratification, as when sands or gravels overlie clay. The section at

Oxford, after Prestwich, which had already appeared on page 42, vol. i. *à propos* of the "Phreatic Water," is again introduced at p. 73, but it is difficult to say that it illustrates anything very special. Numerous other sections are given in illustration of the subject. Contact by accidents posterior to the stratification is next considered; such as the accumulation of water in decomposed granite or growan, the granite itself being of an impermeable nature. Then, again, there are the phenomena presented by slips or talus, such as that shown at the source of the Creux-du-vent, where the spring has been displaced by a great slip on the flanks of a precipice of Jurassic rock (p. 93, vol. i.). There are also great accumulations of water in porous volcanic ejectamenta, which are thrown out in contact with more compact rocks. Some curious instances in Central France are given with plans and pictorial illustrations. Faults, of course, are well known to produce springs by bringing sandstones, limestones, etc., against clays. Such an one occurs in the neighbourhood of Loudun, where Mesozoic beds are represented (section, vol. i. p. 111) as being traversed by a fault of considerable throw, which is vertical or even slightly reversed.

The most important chapter in the book is entitled "Rôle des lithoclases de divers ordres." M. Daubrée has a partiality for subdivision; and, as we have already seen, for Greek compounds. He had previously given us some interesting phenomena in connection with faults (failles), but much the same things now figure under the far grander title of "paraclases." Joints he calls "diaclases"; whilst another class of fractures, many exceedingly minute, he calls "leptoclases." To a subdivision of this latter, called "synclases," he refers those fractures due to contraction. The whole are summarized under the general term "lithoclases." The upshot of all this is, that rocks are fractured in various ways, by various agencies and in different degrees, and of course such fissures facilitate the accumulation and circulation of underground waters. Under the general heading of "lithoclases" he appears to include the artificial piercing of rocks and artesian borings.

Mons. Daubrée has now fairly settled down to his work (Rôle des lithoclases), and once more takes us through the formations in succession, no longer dealing with the mere top-water (Phreatic) of ordinary wells, however deep, but showing us the mechanism of underground waters in its more complex phases. Considered as a whole the Paris basin is eminently suitable for the making of artesian wells. The beds there are disposed in the form of bowls of decreasing size placed one within the other, the position of Paris itself being almost central with regard to them. These formations, alternately permeable and impermeable, are very slightly disturbed; many levels furnish hundreds of artesian wells, whose depth varies habitually from 10 to 30 mètres. For further particulars he refers to the "Guide du sondeur" by Degousée and Laurent. These remarks refer to the Tertiaries, and under the same heading he gives us an interesting account of artesian borings in the Sahara of Touggourt, to the south of Biskra. The first artesian wells of this

region (the Oued-Rhir) are very ancient, and there are reasons for supposing that the employment of this method of obtaining water was older than the Arab conquest of the country. He then enumerates and partly illustrates by plan and section, as many as five distinct artesian basins, in a traverse from south to north through the Province of Constantine, corrresponding to the undulations of the Quaternary (?) beds of the Sahara.

Under the heading "terrains crétacés" important plans and sections are given of localities in France. Not the least interesting are the phenomena in the Department of the Aube, where the waters percolating the porous Upper Chalk are thrown out by the lower marls. It is thus that the base of the chalk cliff is marked by numerous springs, some of them powerful enough to turn mills; amongst these is the source of the Vanne beneath the village of Fontvannes, which affords a supply of water to Paris itself. The spring of La Folletière in the Calvados boiling up from the glauconitic chalk is pictorially represented. But the most important of all under the heading "Cretaceous" is the account given of the artesian borings at Paris itself, which, as previously observed, is in the centre of one of the most perfect basins perhaps to be found anywhere. The boring at Grenelle, which occupied seven years, after traversing some 50 mètres of Tertiary beds and the whole of the White and Grey Chalk, attained a depth of 547 mètres, when water was found abundantly in the Greensand. A section of this pioneer deep-boring, drawn to scale, together with certain well-known buildings of Paris for comparison, will be found on page 210, vol. i. Many interesting details of subsequent borings are also given. Dealing with the English Cretaceous, Mons. Daubrée reproduces some of the sections of Mr. Lucas with respect to the North Downs, and of Mr. Robert Mortimer with respect to the Chalk Wolds of Yorkshire. From the latter writer many interesting facts connected with this subject are abstracted; but a portion of these is unfortunately placed under the heading "Oxfordshire and Whitshire," betraying an indifference to British geography of which we have a further example (p. 351, vol. i.), where the author seems to fancy that the Swallow-holes of Ingleborough and Castleton are in the neighbourhood of Bristol! Still dealing with the Cretaceous, he adduces many important instances in relation to springs, etc., more or less illustrated by plans and sections, from the north of France, Belgium, Westphalia, etc., touches very briefly upon Ireland, and concludes by reproducing some very elaborate sections by M. Dru relative to the Caucasus.

The beds of Jurassic age, as M. Daubrée remarks, with their fissured limestones and stiff marls or clays, are eminently calculated to produce springs. Many interesting cases are quoted, and amongst others he reproduces a section through Rutland by Prof. Judd, which is intended to show two separate water-lines, one at the junction of the Inferior Oolite and Upper Lias, the other at the junction of the Marlstone-rock with the clays of the Middle Lias. We may here take the opportunity of observing that few places in England present

such a number of boiling springs, or river-heads, as does the Vale of Pickering in East Yorkshire, where the porous and fissured Tabular Hills, composed mainly of Corallian rocks, sloping and dipping to the south, are underlain by Oxford Clay, and faulted against the Kimmeridge Clay, capped by Drift, forming the Vale itself. This region illustrates most admirably not only the "Rôle des lithoclases," but also the "Rôle du contact," etc.

After dealing with the Trias and Permian, the Palæozoic and Crystalline rocks, M. Daubrée concludes this important chapter by considering the phenomena in connection with metalliferous veins. But that these latter are discussed more fully in the companion work (Les eaux souterraines aux époques anciennes), the subject might seem to be treated somewhat briefly, since, from a geological point of view, there can be no more interesting theme than the connection between existing mineral springs and the associated deposits in the fissures through which such waters have passed. Instances are quoted from Plombières, Carlsbad, etc.; in the latter case with ample illustration, the main point being to show that the hot springs of the region of the Sprudels occur at the intersection of two systems of fracture.

The part played by caves in the system of underground waters is treated fully by the author; and since this division of the subject lends itself to pictorial illustration, there are several photographs of well-known sources. The fountain of Vaucluse is one so celebrated that Mons. Daubrée dwells at considerable length on its details as related by the MM. Bouviet. Truly a river of limpid water, full of trout and eels, issuing out of the hard and arid Urgonian limestone, it is just one of those spots which have given rise to all sorts of ingenious and even romantic speculations. It seems to be the sad mission of scientific inquiry to knock all these sort of notions on the head. Given a region of some hundreds of square kilomètres of arid limestone without springs or wells, and at the same time seamed by dry ravines—if rain falls on such a desert in any quantity, a portion of this water must have an outlet somewhere. The conditions which determine the discharge are perhaps more complex than in the case of mere surface drainage.

The remainder of Book I. is occupied with the consideration of the phenomena of water forced upwards by the pressure of its own or of other gases. The various sprudels and so-called mud volcanoes come under the latter denomination. Very interesting details are given of a boring at Montrond (Loire). The phenomena of geysers are then dealt with, not forgetting those of the Yellowstone Park, and of New Zealand. Before dealing with actual volcanoes, M. Daubrée introduces the subject of "soffionis," *i.e.* jets of vapour endowed with a high temperature, which are projected from certain fractures of the ground. The best examples of this class occur in the boracic arid district of Tuscany, of which a tolerably full account is given, accompanied by many illustrations. According to the section (vol. i. p. 405), the country consists of Pliocene clays, Eocene limestone and shales, Cretaceous beds and Lias, all considerably plicated,

and having a bed of serpentine interposed between the two Tertiary deposits. The pipes supplying the soffionis are represented as cutting across the several formations, but no suggestion as to their primary source is offered. With respect to volcanoes, M. Daubrée observes that in spite of the idea which they suggest generally of melted rocks originating in the dry way (voie ignée)), before all things they represent supplies of water, since everywhere the vapour of water is one of the principal products of their activity. An effective cut of the explosion of Krakatau helps to illustrate this.

Book II. supplies us with some valuable facts relative to the temperature both of cold and hot springs.

Book III. deals with the composition of underground waters, First of all the author enumerates the substances dissolved or chemically deposited by them. Speaking generally, one may say that nearly all the elements or their primary compounds exist dissolved in water *somewhere*, either with or without the aid of other solvents; but sulphur, silica, and carbonate of lime are amongst the most abundant deposits. By way of illustration Mons. Daubrée gives a photograph of the mud springs with sulphur at Crater Hill after Hayden, and many other pictorial representations of silica and limestone deposits, taken from various quarters of the globe. Most of these are now in full operation. Compounds of aluminium are rare; nevertheless the hydrous silicates of that mineral, such as allophane, are still being deposited. With respect to the classification of mineral waters Mons. Daubrée will not admit of any preconceived ideas: the predominating substances must decide the grouping. The families are classified according to the principal electro-negative element, as chlorides, sulphides, sulphates, carbonates and silicates: the genera by the principal electro-positive (basic) element, as sodic, calcic, magnesic, etc. Under such an arrangement the waters of the Old Sulphur Well at Harrogate, which is a "strong saline sulphur" containing about 1000 grains of haloid salts to the gallon, would be classified as a brine, in spite of its free hydrogen sulphide and its five grains per gallon of sodium sulphydrate appealing alike to the taste and smell. At the same time it is not easy to say where Mons. Daubrée would draw the line, since he cites a spring at Barèges as a sulphur water which contains 0·04 grms. of sulphide of sodium to the litre out of 0·11 grms. of fixed substances, *i.e.* rather more than one-third. This is what would be called a "pure sulphur water" in the language of the Harrogate doctors.

The silicated waters (sources silicatées), as Mons. Daubrée justly observes, are of the highest interest to the geologist. The silica would usually seem to be in combination with soda, but weighable quantities of the silicates of lime, magnesia and alumina have been found in a water of the Hautes-Pyrénées.

After glancing at the reactions of underground waters on the material bathed by them, the author proceeds to consider the origin of the substances dissolved in the water or chemically deposited by them. Amongst the most obvious are the filth of cities draining into rivers and contaminating the waters of shallow wells; then

there are rocks soluble in water, such as rock-salt and gypsum, and the carbonates, which require the aid of free carbonic acid in the waters, rocks whose decomposition produces soluble matter such as pyrites, etc., etc. Also water charged with saline matter probably possesses greater solvent powers over certain substances. The author then considers the principal elements and source of these compounds in succession in a tolerably long chapter.

In a fourth book Mons. Daubrée makes some general observations relative to the subject, and especially discusses the origin of the temperature of underground waters. Again he illustrates the subject with numerous sections, showing from instances culled in all directions how the result may be influenced by plications of the strata at high angles, whereby the waters are drawn down through synclinal folds to depths where considerable elevation of temperature obtains. Even extinct volcanoes, and rocks of volcanic origin, such as basalts and trachytes, retain sufficient heat to influence the waters which percolate them. Asia Minor, for instance, is a country exceptionally rich in thermal springs. The subject of geysers and volcanoes is again resumed. With regard to the latter, Mons. Daubrée quotes Mr. W. L. Green, who has studied the Hawaiian volcanoes, to the effect that in the eruptions of that archipelago the vapour of water has only played a secondary part. This is an important quotation in view of M. Daubrée's previous assertions with respect to the functions of underground waters in these phenomena. It also bears upon a question which has of late much engaged the attention of Prof. Prestwich and other writers. Lastly, Mons. Daubrée discusses the part which water may play in earthquakes.

An index of subjects, a second of localities, and a third of authors, accompanies the work, which, although having no special claim to originality, constitutes a valuable text-book on the question of underground waters, considered under almost every aspect which can well be conceived. For geological purposes it also affords a good introduction to the companion work already noticed, which is likewise provided with copious indexes.

W. H. H.

REPORTS

Geological Society of London.

November 23, 1887.—Prof. J. W. Judd, F.R.S., President, in the chair.—The following communications were read:—

1. "Note on a New Wealden Iguanodont, and other Dinosaurs." By R. Lydekker, Esq., B.A., F.G.S.

The new species of *Iguanodon* was founded upon a left ilium and ischium, parts of the pubis and tibia, two metatarsals, several dorsal lumbar and caudal vertebræ and other bones, obtained by Mr. C. Dawson, F.G.S., from the Wadhurst clay of the Hastings Sand. The species now described, which was named after the discoverer,

and *Iguanodon Prestwichi*, were shown to form a peculiar and aberrant group of the genus *Iguanodon*. A maxilla from the Wealden of the Isle of Wight was also described and referred to *Ornithopsis*.

The recent examination by the author of the remains of Dinosauria in the British Museum for the purpose of preparing a catalogue, had enabled him to make several notes on the various forms represented in the collection, and these notes were embodied in the present paper. The principal subjects mentioned were the following:—The identification of *Iguanodon Seeleyi* with *I. bernissartensis*; the genera *Sphenospondylus* and *Cumnoria* of Prof. Seeley; a British species of *Trachodon* from the Cambridge Greensand; an ilium, provisionally referred to *Hylæosaurus*, from Cuckfield; the genera *Vectisaurus* and *Regnosaurus*; the relations of the Sauropoda and Theropoda; the type specimen of *Ornithopsis Hulkei*; the similarity of the humerus in *Pelorosaurus* and *Brontosaurus*; the vertebræ and other remains of *Cetiosaurus brevis*; the humerus of *C. humerocristatus* and its relations to *Ischyrosaurus*, Hulke, *Gigantosaurus*, Seeley, and *Ornithopsis Leedsii*, Hulke; the affinities between *Cetiosaurus oxoniensis* and *Morosaurus*; the occurrence of *Titanosaurus* in the Wealden of England and the possible identification of that genus with the *Dinodocus* of Owen; the vertebræ described by Owen as *Bothriospondylus magnus*; the types of the genera *Thecospondylus* and *Bothriospondylus*; and some Megalosaurian teeth.

2. "On the Cae-Gwyn Cave." By T. McKenny Hughes, M.A., F.G.S., Woodwardian Professor of Geology, Cambridge.

The subject fell into two divisions: The Age of the Drift outside the Cave, and The relation of the deposits in the Cave to that Drift. The author contended that the drift outside the cave was a marine deposit *remanié* from older beds of glacial age, but was itself postglacial and of approximately the same date as the St. Asaph drift; in confirmation of which he gave the following list of shells from that drift outside the cave:—*Ostrea edulis, Pecten varius, Mytilus edulis, Cardium echinatum, C. edule, Cyprina islandica, Astarte borealis, A. sulcata, A.* var., *Venus gallina, Tellina balthica, Psammobia ferroensis, Mya truncata, Fissurella græca, Littorina littorea, Turritella terebra*, and *Buccinum undatum*; pointing out that there was only the one species of *Astarte* among them which was not common on the adjoining coast, just as there were in the older postglacial river-gravels of the S.E. of England two locally extinct forms, the *Corbicula fluminalis* and the *Unio littoralis*, and discussing various difficulties, stratigraphical and palæontological, in the way of accepting the view that the cave-deposits were glacial, interglacial, or preglacial. For instance, he remarked that there were no marks of glaciation on the face of the rock in which the cave occurred; that the cave-deposits were like drift because derived from it, but that no continuity existed between the drift and the cave-deposits; that there was a much greater thickness of rain-wash and resorted marine-drift looped down over the upper opening into the cave than over the adjoining surface. The upper part of this

resorted drift is exactly similar to the material which had accumulated against the old fence, the very existence of which had been denied. The swallow-hole action to which he referred the phenomena was proved by the opened fissures and vertical cylindrical holes in the limestone and by the occurrence of a land-shell (*Zonites cellarius*). He held that there had been a breakdown of the roof and wall of the cave under the drift, and that angular masses of limestone, due to this cause, were found all along in front of the upper opening to the cave. No bones were found outside that barrier, there being no bones in the shell-bed and no shells in the bone-bed except the land-shell washed down through a fissure.

Instead, therefore, of the difficult task of proving that there were in the district many well-known processes connected with subterranean denudations, which might explain the superposition of the marine drift upon the bone-earth, each of which had played a part in producing the results observed, he maintained that we had now the clearest evidence as to the exact manner in which it was all brought about, namely, that the marine drift was deposited before the occupation of the cave by the animals whose remains have been found in it; that at the time of the occupation of the cave the upper opening now seen did not exist, but the animals got in by the other entrance; that against the wall of the cave where it approached most nearly to the face of the cliff, the drift lay thick as we now see it; that by swallow-hole action the cave was first partially filled, and then the thinnest portion of its wall gave way gradually, burying the bone-earth below it, and letting down some of the drift above it, so that some of it now looks as if it might have been laid down by the sea upon preexisting cave-deposits.

II.—December 7, 1887.—Prof. J. W. Judd, F.R.S., President, in the chair.—The following communications were read:—

1. "A Letter from H.M. Secretary of State for the Colonies, enclosing an account of recent Discoveries of Gold in the Transvaal."

The deposits in which gold has been found, locally known as "banket," consist of a quartz-conglomerate forming so-called "reefs," which traverse the veldt paralled to, but at a short distance from the rocky ridge of Witwatersrand. These masses always dip to the south, but at angles varying from 30° up to 90°. The "reefs" are believed to have been discovered by Mr. Struben, an English gentleman long resident in the country. The "main reef" has been traced for twenty-five or thirty miles, and varies in breadth from 3 feet 6 inches to 15 feet; parallel and branching "reefs" of smaller dimensions have also been found. The yield of gold is said to be very variable in different portions of the "reef," different samples with from 3 oz. to ½ oz. per ton occurring in close proximity. So far as observation has gone (and the deepest workings have only reached a depth of from 70 to 150 feet), the yield of gold has generally increased as the reefs are followed downwards.

2. "On the Age of the Altered Limestone of Strath, Skye." By Dr. Archibald Geikie, F.R.S., V.P.G.S.

The remarkable alteration of the limestone of Strath into a white saccharoid marble, first described by Macculloch, has hitherto been regarded as an instance of contact-metamorphism in a rock of Liassic age. The various writers who have described the geology of the district have followed Macculloch in classing the whole of the ordinary and altered limestone with the Secondary series of the Inner Hebrides. The author, however, saw reason in 1861 to suspect that some part of the limestone must be of the age of the Durness Limestone of Sutherland, that is, Lower Silurian; and he expressed this suspicion in a joint paper by the late Sir R. I. Murchison and himself, published in the 18th volume of the Quarterly Journal of the Society. He has recently returned to the subject, and now offers lithological, stratigraphical, and palæontological evidence that the altered limestone is not Lias, but Lower Silurian.

In lithological characters the limestone, where not immediately affected by the intrusion of the eruptive rocks, closely resembles the well-known limestones of the west of Sutherland and Ross-shire. It is not more altered than Palæozoic limestones usually are. It contains abundant black chert-concretions and nodules, which project from the weathered surfaces of the rock exactly as they do at Durness. These cherts do not occur in any of the undoubted Lias limestones of the shore-sections. The limestone lies in beds, which, however, are not nearly so distinct as those of the Lias, and have none of the interstratifications of dark sandy shale so conspicuous in the true Liassic series.

The stratigraphy of the altered limestone likewise marks it off from the Lias. There appears to be a lower group of dark limestones full of black cherts, and a higher group of white limestones with little or no chert, which may be compared with the two lower groups of the Durness Limestone. A further point of connexion between the rocks of the two localities is the occurrence of white quartzite in association with the limestone at several places in Strath, and of representatives of the well-known "fucoid beds" at Ord, in Sleat. These latter strata form a persistent band between the base of the limestone and the top of the quartzite, which may be traced all the way from the extreme north of Sutherland southward into Skye.

Palæontological evidence confirms and completes the proof that the limestone is of Lower Silurian age. The author has obtained from the limestone of Ben Suardal, near Broadford, a number of fossils which are specifically identical with those in the Durness Limestone, and so closely resemble them in lithological aspect that the whole might be believed to have come from the same crag. Among the fossils are species of *Cyclonema, Murchisonia, Maclurea, Orthoceras,* and *Piloceras.*

The relations of the limestones containing these fossils to the other rocks were traced by the author. He showed that the Lias rests upon the Silurian limestone with a strong unconformability, and contains at its base a coarse breccia or conglomerate, chiefly composed of pieces of Silurian limestone, with fragments of chert and quartzite. The metamorphism for which Strath has been so long noted is con-

fined to the Silurian limestone, and has been produced by the intrusion of large bosses of granophyre (Macculloch's "syenite") belonging to the younger, or Tertiary series of igneous rocks.

3. "On the Discovery of Trilobites in the Upper Green (Cambrian) Slates of the Penrhyn Quarry, Bethesda, near Bangor, North Wales." By Dr. Henry Woodward, F.R.S., V.P.G.S.

The absence in Wales of organisms in the Longmynd and Harlech group renders any discovery of fossils in beds of this early horizon of the utmost importance.

A portion of a Trilobite (*Palæopyge Ramsayi*) and Annelide burrows had already been found; but Dr. Hicks, at St. Davids, has added a sponge, 2 Ostracods, 6 Trilobites, 2 *Lingulellæ*, and 2 *Thecæ* (*Agnostus*, *Plutonia*, *Paradoxides*, *Conocoryphe Lyelli*, *C. bufo*, and *Microdiscus sculptus*).

Dr. Hicks has pointed out the singular absence of organic remains in the Longmynds both in Shropshire, N. Wales, and Ireland, and has urged the need of further explorations. As if in answer to this, the author has received from Prof. Dobbie an impression and counterpart of a Trilobite from Bethesda, near Bangor, about 3½ in. long and 1¾ in. broad, also the head of a second specimen of the same species. These specimens were obtained from the Upper Green bed of the quarry, which immediately underlies the grits forming the brow of Bronllwyd and overlies the Purple Slate. The glabella is marked by three oblique furrows on each side, the cheek-sutures are very obscure, and the eyes, which are minute (probably rudimentary), occupy the centre of the free cheek, the suture obliquely dividing the free cheek from the fixed. The outline of the head is rounded. There are fourteen free thoracic segments. The pygidium consists of about three coalesced somites.

Comparing the Bangor fossil with *Paradoxides*, we find that *Paradoxides* has about twenty free segments.

Asaphus, *Ogygia*, and *Niobe* have only eight thoracic rings, and the caudal shield is very large.

Angelina agrees with the Bethesda specimen in the number of its free segments; but the glabella is smooth, the pleuræ are broader, and the cheek-spines very long.

Olenus has fourteen rings; the glabella is furrowed, but the head-shield is shorter and broader, and the ends of the pleuræ and margin of the caudal shield are usually produced into spines. *Olenus* is also smaller.

Conocoryphe has fourteen free segments; the axis is parallel-sided, and does not diminish backward from the head to the pygidium; each ring of the axis is notched on its posterior border, and the ends of the pleuræ are rounded; the glabella is furrowed obliquely; the eyes are often wanting or are minute.

From these considerations the author concludes the Bangor fossil to be referable to *Conocoryphe*, and to a new species, *C. viola*.

The Trilobite was found by Robert E. Jones and Robert Lloyd, two quarrymen, at Bethesda. Afterwards Prof. Dobbie found a detached head of the same species near the spot where the original

specimen was obtained. The author desires to return thanks to Prof. J. Dobbie, of the University College of North Wales, Bangor, for the opportunity of describing these specimens.

4. "On *Thecospondylus Daviesi*, Seeley. with some Remarks on the Classification of the Dinosauria." By Prof. H. G. Seeley, F.R.S., F.G.S.

The author described the anterior third of a vertebra from the Wealden, which was recognized by Mr. Davies as the cervical vertebra of an animal allied to the genus *Cœlurus*, Marsh. The only European genus hitherto described in which the vertebræ are similarly elongated, compressed, and enveloped in a dense external film of bone is that indicated by the sacrum, named *Thecospondylus Horneri*, whose vertebræ are about 11 centimetres long, whilst the cervical vertebræ now under discussion were 9 centimetres long when complete. The specimen has lost the prezygapophyses and cervical ribs. If these were restored, they would probably approximate in shape to those of *Cœlurus fragilis*.

The author gave an outline-restoration. The points of resemblance were chiefly the elongated form, lateral compression of centrum and neural arch, inclined articular face of centrum, mode of attachment of the ribs, the convex external surface of the neural arch, almost total suppression of the neural spine, and the thin texture of the bone. But this affinity does not amount to generic identity, and he indicates the points of difference. In estimating the resemblance to *Thecospondylus* he regards the thinness of the investing layer of bone, the smoothness of its internal surface, and the elongation and lateral compression of the vertebræ, and a certain general approximation in form; the most remarkable difference is the absence from the cast of *Thecospondylus Horneri* of indications of films of bone, or evidence of internal plates. such as are seen in the present specimen. He observed that Prof. Marsh regards *Cœlurus fragilis* as a generalized Sauropsid, with more resemblance to Dinosaurs than to Pterodactyles.

Professor Marsh has formed an Order, Sauropoda, which includes *Cetiosaurus* and *Ornithopsis*. The author remarks that he had already suggested Cetiosauria as separable from the rest of the Dinosaurs. When an additional Order is instituted for animals with cavernous or pneumatic vertebræ, the Theropoda of Marsh, under which *Cœlurus* is grouped, it becomes necessary, in order to determine the systematic position of *Thecospondylus*, to review its relations. The author would unite Sauropoda with Theropoda into one Order, the Saurischia, whose pneumatic skeleton is an approximation towards Ornithosaurs and Birds.

CORRESPONDENCE.

CLASSIFICATION OF THE DINOSAURIA.

Sir,—Will you allow me to state that I did not forward to the Geological Magazine the abstracts of my British Association papers printed in the December Number, pp. 561–563, and that no proof of those abstracts was submitted to me; so that I am not responsible

for the publication. In the paper on the classification of the Dinosauria, I do not adopt the names given on p. 562; but use the name *Ornithischia* for the order of which Omosaurus is an example, there named Omosauria; while the name *Saurischia* is used for the order comprising allies of Cetiosaurus, there named Cetiosauria. I shall be glad if this erratum is corrected on p. 562, so that the names which appear there may not be quoted, and may be considered not to have been published.

The Vine, Sevenoaks, *Dec.* 3, 1887. H. G. Seeley.

DIMETIAN OF ST. DAVIDS.

Sir,—Mr. Mellard Reade in his paper "On the Dimetian of St. Davids" does not state whether the rock which he found included in the "Dimetian," and which he calls a "green shale," has been proved to be such by microscopic examination. Will he kindly supply the omission; because, without such an assurance, his proof of the intrusive character of the "Dimetian" has no more validity than an arch without a keystone. T. G. Bonney.

PROF. BONNEY ON BANDED GNEISSES AND THE METAMORPHIC ROCKS OF SOUTH DEVON.

Sir,—Would you kindly allow me space for reply to Professor Bonney's letter in your issue for December, on the above subjects, more especially the latter, which directly affects myself. This portion of his letter forms a marked contrast to the other, and at the outset I beg to protest against its style and tone, which I shall not condescend to imitate in this reply.

It is possible or even probable that I may be wrong in my interpretation of these South Devon rocks, and if so, on further and better proof I shall be as happy in the opposite conclusion, as I earnestly trust that I follow science or truth for its own sake.

With regard to the use of the microscope in geology, let me respectfully remind Prof. Bonney that it is not everything. It so happens that I too have a stake in the "banded gneisses" of the Lizard district, and my field-work there showed me that the whole of his "granulitic" group of schists were rocks of true igneous origin, a fact forced upon me without the aid of the microscope; and further, that the other schists in which the Professor describes current-bedding and ripple-drift, etc., etc., I strongly suspected to have had also an igneous origin, and these appearances due to very different causes, facts which have since been corroborated by a high authority. So much for the use and non-use of the microscope, an instrument in research which I do not undervalue, and which I mean to become better acquainted with.

It is, however, against the tone of the Professor's letter that I complain, and I would invite him (and the rest of your interested readers) to compare the portion of it relating to myself with the last paragraph of his own article in "Nature" for November 10th.

59, Fleet Street, Torquay, *Dec.* 15, 1887. Alex. Somervail.

THE MAMMOTH AND THE FLOOD.

We have received a somewhat lengthy communication from Mr. H. H. Howorth, M.P., in which he reminds us that so recently as 1880 Sir Andrew Ramsay expressed the opinion that "from the Laurentian epoch down to the present day, all the physical events in the history of the earth have varied neither in kind nor in intensity from those of which we now have experience." (Address to Geol. Section, Brit. Assoc., Swansea.) We are glad to be in sympathy with Mr. Howorth in his opposition to this doctrine, but we do not believe it is upheld by many geologists at the present day, nor is it taught in modern text-books. (See Geology, by A. H. Green, Ed. 3, 1882, pp. 694—696; Text-Book of Geology, by A. Geikie, Ed. 2, 1885, pp. 3, 178; Outlines of Geology, by James Geikie, 1886, p. 3.)

Mr. Howorth contends that over the greater portion of the Earth's surface there is no such denudation going on (or even possible) as that which has taken place in past times. We have not disputed the notion that excessive denudation may have taken place in former times, for instance, during the Glacial period. Mr. Howorth, however, objects to the employment of the term Denudation to include the action of springs and rivers in carrying away the soluble constituents of rocks! We are aware that *literally* the term is inapplicable, but in nearly every geological work it is used to signify the removal of material from any portion of the land. Mr. Jukes-Browne has indeed suggested that the word Detrition be used in this sense in place of Denudation, but we are averse to the introduction of new names, when the old ones are sufficiently intelligible. In reference to this subject we may refer Mr. Howorth to a work by Mr. Mellard Reade on "Chemical Denudation in relation to Geological Time." EDIT. GEOL. MAG.[1]

THE DIMETIAN OF ST DAVIDS.

SIR,—Mr. Mellard Reade's paper in the GEOLOGICAL MAGAZINE for December on the Dimetian of St. Davids contains such striking evidence of a want of acquaintance with the subject, and such hasty conclusions founded on erroneous observations, that I should not consider it necessary to reply to it, were it not that a definite piece of so-called evidence is given which may lead to some misapprehension if not corrected.

The piece of evidence which he gives to prove "that the rock is not in any sense Archæan, but is post-Cambrian, and intrusive," occurs in the following passage relating to the sections at Porthclais: "At a distance of about 30 feet north of this contact and embedded in the granite is a vein of green shale about 18 inches across and another about 10 feet nearer to the contact about six inches across.

[1] As Mr. Howorth reminds us in his letter that the more important issues raised by his Reviewer (see GEOL. MAG. October 1887, p. 473) can only be properly discussed when his second volume appears, we are content to await the issue of that work—the limited space at our disposal not admitting of the publication of lengthy letters in reply to Reviews.—EDIT. GEOL. MAG.

Both these veins of shale, but especially the thinner one, have a rudely columnar structure at right angles to their direction. Excepting that this shale is a little more indurated and more like slate in its constitution, it is similar to the Cambrian green shales that overlie the basal conglomerate. These veins are in my view undoubtedly part of the Cambrian shale entangled in the granite, so that the granite must be post-Cambrian."

Now, Sir, these veins are perfectly well known to all who have examined the sections at Porthclais, but it has been reserved for Mr. Reade to venture to call them Green Cambrian Shales. Those who have examined these veins with any care have had no difficulty in recognizing in them the ordinary behaviour of igneous rocks, and in proving after a microscopical examination that they are diabase dykes! Such dykes, as is well known, are common in the Dimetian, and they have been frequently referred to in my papers. Mr. Reade would therefore have acted more wisely, if, before publishing his views, he had taken the trouble to read more of what had been written on the subject, and also had consulted a petrologist as to the nature of the rocks he was dealing with.

HENDON, *Dec.* 3, 1887. HENRY HICKS.

ON *ETOBLATTINA*, A LARVAL COCKROACH FROM THE COAL-MEASURES OF KILMAURS, AYRSHIRE; DISCOVERED BY MR. LINTON, OF KILMARNOCK.

MY attention has been called by Mr. Robert Kidston, F.G.S., to a serious omission made by me in my notice of *Etoblattina Peachii* in the GEOLOGICAL MAGAZINE for October, 1887, p. 432.

It is true that the specimen was forwarded to me by my friend, Mr. B. N. Peach, of the Geological Survey of Scotland, but I am now informed that it was found by a private geologist, Mr. Linton, of Kilmarnock,[1] and he it was (and not the friend who sent it to me) whom I should have specially mentioned as being the discoverer. I regret exceedingly my carelessness in not making further inquiries of Mr. Peach as to its ownership before setting out to describe this interesting Carboniferous treasure, and I take this opportunity to thank Mr. Linton most cordially for placing it so generously at Mr. Kidston's disposal for examination. We are all so deeply indebted to the persevering labours of such private geologists, as Mr. Linton, that I, for one, would be the last to omit to award them their full meed of honour.

129, BEAUFORT STREET, S.W. HENRY WOODWARD.

[1] This gentleman entrusted it to Mr. Kidston to be described. Mr. Kidston transferred it to Mr. Peach, who subsequently transmitted it to the writer.—H.W.

WESTERN AUSTRALIA.—MR. HARRY PAGE WOODWARD, F.G.S., F.R.G.S. (eldest son of Dr. Woodward, F.R.S., V.P.G.S.), who served for more than three years under Mr. H. Y. L. Brown, F.G.S., as Assistant Government Geologist in South Australia, has been appointed by Her Majesty's Secretary of State for the Colonies to the post of Government Geologist for Western Australia. Only a very small portion of this, the largest of the Australian Colonies, has at present been examined by a geologist. Mr. Woodward left for Perth on the 2nd of December last.—*The Times*, Dec. 8, 1887.

FIG. 1.

FIG. 2.

SPECIMENS OF EOZOÖN CANADENSE (DAWSON), TO ILLUSTRATE SIR J. W. DAWSON'S PAPER (p. 49).

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. V.

No. II.—FEBRUARY, 1888.

ORIGINAL ARTICLES.

I.—Note on New Facts relating to Eozoon Canadense.[1]

By Sir J. William Dawson, LL.D., F.R.S., etc., etc.

(PLATE IV.)

THE late Dr. Carpenter had undertaken an elaborate series of investigations of Eozoon, based on all the material collected by myself and others in Canada, with the view of preparing a complete and exhaustive memoir on the subject. In consequence of this arrangement the new facts obtained for several years have remained unpublished. Unhappily the work was left at his lamented decease in a very incomplete state.

The present note is intended, without entering into any controverted points, to notice some new facts respecting the fossil and its state of preservation, which have been disclosed within the few past years.

1. *Form of Eozoon Canadense.*

Hitherto this has been regarded as altogether indefinite, and it is true that the specimens are often in great confluent masses or sheets, the latter often distorted by the lateral pressure which the limestone has experienced. The specimen from Tudor, however, figured by Sir W. E. Logan in the 'Quarterly Journal of the Geological Society,' 1867, p. 253, and that described by me in the 'Proceedings of the American Association' in 1876, and figured in my work "Life's Dawn on Earth," gave the idea of a turbinate form more or less broad. More recently additional specimens weathered out of the limestone of Côte St. Pierre have been obtained by Mr. E. H. Hamilton, who collected for me at that place; and these, on comparison with several less perfect specimens in our collections, have established the fact that the normal shape of young and isolated specimens of *Eozoon Canadense* is a broadly-turbinate, funnel-shaped, or top-shaped form, sometimes with a depression on the upper surface giving it the appearance of the ordinary cup-shaped Mediterranean sponges. (See Pl. IV. Fig. 1.) The photographs exhibited show this appearance in two specimens. These specimens also show that there is no theca or outer coat either above or below, and that the laminæ pass outwards without change to the margin of the form, where, however, they tend to coalesce by subdividing and bending together. The laminæ are thickest at the base of the inverted cone, and become thinner and closer on ascending, and at the top they

[1] Read at the Meeting of the British Association, Sept. 5, 1887.

become confounded in a general vesicular or acervuline layer. I feel now convinced that broken fragments of this upper surface scattered over the sea-bottom formed those layers of *Archæosphærinæ* which at one time I regarded as distinct organisms.

It is to be observed, however, that other forms of Eozoon occur. More especially there are rounded or dome-shaped masses, that seem to have grown on ridges or protuberances, now usually represented by nuclei of pyroxene.

2. *Pores or Oscula.*

In the large number of specimens of Eozoon which have been cut or sliced in various directions, and are now in our Museum at Montreal, it has become apparent that there are more or less cylindrical depressions or tubes, sometimes filled with serpentine and sometimes with inorganic calcite, crossing the laminæ at right angles. These seem to occur chiefly in the large and confluent masses, and are without any regular or definite arrangement. In some of the narrower openings of this kind the laminæ can be observed to subdivide and become confluent on the sides of these tubes in the same manner as at the external surface. This circumstance induces me to believe that these are not accidental, but original parts of the structure, and intended to admit water into the lower parts of the masses. A characteristic example of a fortunately weathered specimen is seen in the photograph accompanying this paper. (See Pl. IV. Fig. 2.) A central canal of a similar kind is well shown in the accompanying illustration.

Section of the base of a turbinate or top-shaped *Eozoön*. This specimen shows an osculiform, cylindrical perforation, cut in such a manner as to show its *reticulated wall* and the descent of the laminæ toward it. Two-thirds of natural size. Coll. Carpenter.

[This illustration (from Prof. Prestwich's "Geology," vol. ii. p. 21) has been courteously lent by the Clarendon Press, Oxford.]

3. *Beds of Fragmental Eozoon.*

If Eozoon was an organism growing on the sea-bottom, it would be inevitable that it would be liable to be broken up, and in this condition to constitute a calcareous sand or gravel. I have already in previous papers described Laurentian limestones containing such fragments from the Grenville band at Côte St. Pierre, from the Adirondack Mountains in New York State, from Chelmsford, Massachusetts, and from St. John, New Brunswick, as well as from Brazil, and the Swiss Alps. Indeed, the Laurentian limestones of most parts of the world hold fragmental Eozoon. In the Peter-Redpath Museum are some large slabs of Laurentian limestone sawn under the direction of Sir W. E. Logan, and showing irregular layers and detached masses of Eozoon with layers or bands of limestone and of ophiolite. These are evidently layers successively deposited, though somewhat disturbed by subsequent movements. On selecting specimens from the white and more purely calcareous layers, I was pleased to find that they abound in fragments of laminæ of Eozoon, having the canals filled either with dolomite or with colourless serpentine. Other portions of the limestone show the peculiar granulated structure characteristic of the calcareous laminæ of Eozoon, but without any appearance of canals, which may in this case be occupied with calcite, not distinguishable from the substance of the laminæ. There are also indications in these beds of limestone of the presence of Eozoon not infiltrated with serpentine, but having its laminæ either compressed together, or with the spaces between them filled with calcite. There are other fragments which, from their minute structure, I believe to be organic, but which are apparently different from Eozoon.

4. *Veins of Chrysotile.*

I have in previous papers abundantly shown that the veins of fibrous chrysotile which abound in serpentinous limestones of the Laurentian are of secondary aqueous origin, as they fill cracks or fissures not merely crossing the beds of the limestone, but passing through the masses of Eozoon and the serpentinous concretions which occur in the beds. They must, therefore, have been formed by aqueous action long after the deposition, and in some cases after the folding and crumpling of the beds. In this respect they differ entirely from the laminæ of Eozoon, which have been subject to the same compression and folding with the beds themselves.

The chrysotile veins have, of course, no connection with the structures of Eozoon, though they have often been mistaken for its more finely tubulated portion. With respect to this latter, I believe that some wrong impressions have been created by defining it too rigorously as a "proper wall." In so far as I can ascertain, it consisted of finely divided tubes similar to those of the canal-system, and composed of its finer subdivisions placed close together, so as to become approximately parallel, as in the photograph No. 4, sent herewith.

5. *Nodules of Serpentine.*

Reference has been made in previous papers to the nodules and grains of serpentine found in the Eozoon-limestone, but destitute of any structure. These nodules, as exhibited in the large slabs already referred to, have however often patches of Eozoon attached to, or imbedded in them, and they appear to indicate a superabundance of this siliceous material accumulating by concretionary action around or attached to any foreign body, just as occurs with the flints in chalk. The layers of grains and serpentine parallel to the bedding appear to be of similar origin.

6. *State of Preservation.*

Recent observations more and more indicate the importance and frequency of dolomite as a filling of the canals, and also the fact that the serpentine deposited in and around the specimens of Eozoon is of various qualities. Dr. Sterry Hunt has shown that the purely aqueous serpentine found in the Laurentian limestones is of different composition from that occurring with igneous rocks, or as a product of the hydration of olivine. There are, however, different varieties even of this aqueous serpentine, ranging in colour from deep green to white; and one of the lighter varieties has the property of weathering to a rusty colour, owing to the oxidation of its iron. These different varieties of serpentine will, it is hoped, soon be analysed, so as to ascertain their precise composition. The mineral pyroxene, of the white or colourless variety, is a frequent associate of Eozoon, occurring often in the lower layers and filling some of the canals. Sometimes also the calcareous laminæ themselves are partially replaced by a flocculent serpentine, or by pyroxenic grains imbedded in calcite.

7. *Other Laurentian Organisms.*

In a collection recently acquired by the Peter-Redpath Museum, from the Laurentian of the Ottawa district, are some remarkable cylindrical or elongated conical bodies, from one to two inches in diameter, which seem to have occurred in connection with beds or nodules of apatite. They are composed of an outer thick cylinder of granular dark-coloured pyroxene, with a core or nucleus of white felspar; and they show no structure, except that the outer cylinder is sometimes marked with radiating rusty bands, indicating the decay of radiating plates of pyrite. They may possibly have been organisms of the nature of *Archæocyathus*; but such reference must be merely conjectural.

8. *Cryptozoum.*

The discovery by Prof. Hall, in the Potsdam formation of New York, and by Prof. Winchell in that of Minnesota, of the large laminated forms which have been described under the above name, has some interest in connection with Eozoon. I have found fragments of these bodies in conglomerates of the Quebec group, associated with Middle Cambrian fossils; and, whatever their

zoological relations, it is evident that they occur in the Cambrian rocks under the same conditions as Eozoon in the Laurentian. I find also in the Laurentian limestones certain laminated forms usually referred to Eozoon, but which have thin continuous laminæ, with spongy porous matter intervening, in the manner of *Cryptozoum* or of *Loftusia*. Whether these are merely Eozoon in a peculiar state of preservation or a distinct structure I cannot at present determine.

9. *Continuity and Character of containing Deposits.*

At a time when so many extravagant statements are made respecting the older crystalline rocks, it may be proper to state that all my recent investigations of the Middle Laurentian vindicate the results of the late Sir William Logan as to the continuity of the great limestones, their regular interstratification with the gneisses, quartzose gneisses, quartzites, and micaceous schists, and their association with bedded deposits of magnetite and graphite, and also the regularity and distinctly stratified character of all these rocks. Farther, I regard the Upper Laurentian, independently of the great masses of Labradorite rocks, which may be intrusive, as an important aqueous formation, characterised by peculiar rocks, more especially the anorthite gneisses. I am also of opinion that the so-called crystalline Huronian rocks of the country west of Lake Superior are stratigraphically, and to a great extent lithologically, equivalent to the Upper Laurentian of St. Jerome and other places in the Province of Quebec, differing chiefly in the greater or less abundance of intrusive igneous rocks.

10. *Imitative Forms.*

The extraordinary mistakes made by some lithologists in studying imperfect examples of Eozoon and rocks supposed to resemble it, and which have gained a large amount of currency, have rendered necessary the collection and study of a variety of laminated rocks, and considerable collections of these have been made for the Peter-Redpath Museum. They include banded varieties of dolerite and diorite, of gneiss, of apatite and of tourmaline with quartz, laminated limestone with serpentine, graphic granites, and a variety of other laminated and banded materials, which only require comparison with the genuine specimens to show their distinctness, but many of which have nevertheless been collected as specimens of Eozoon. I do not propose to enter into any detailed description of these here, but hope, with the aid of Dr. Harrington, to notice them in forthcoming Memoirs of the Peter-Redpath Museum.

POSTSCRIPT.—It has been suggested by Mr. Julien[1] and others that Eozoönal structure may be due to the alternation of mineral layers formed in the passage-beds between concretions and their enclosing mass. The objections to this view are:

1. Laminated passage-rocks and laminated concretionary forms

[1] Proceed. Amer. Assoc. vol. xxxiii. 1884, pp. 415, 416.

have only simple laminæ, whereas *Eozoon* has connected or reticulatory laminæ.

2. Laminated passage-rocks have no structure other than crystalline. *Eozoon* has beautiful tubulation in its calcareous walls, besides large tubes or oscula.

3. Sometimes (not usually) pyroxene is the siliceous part of *Eozoon*; or, as we hold, the mineralizing agent. More usually it is serpentine, sometimes loganite, or dolomite, or mere earthy limestone. It is not possible that all these minerals should assume the same forms.

4. Pyroxene and serpentine both occur in nodules and bands in the Laurentian limestones, and in most cases without any traces of *Eozoon*, while *Eozoon* occurs in the limestone remote from such nodules and bands, where no passage of any kind can occur, and presents distinct forms.

5. There are only two localities known to me, one in a quarry near Côte St. Pierre, and one at Burgess, where a bed with badly-preserved *Eozoon* occurs in a manner which would not even suggest an idea. Pyroxene is present in the one case, and loganite in the other.

6. I have often thought of this suggested explanation, and have compared *Eozoon* with all sorts of banded and passage-rocks taken from the Laurentian and other formations, but have seen no reason to adopt such a view for *Eozoon*. I may add that in the Peter-Redpath Museum at Montreal I have accumulated a very large number of laminated and passage-rocks and concretions for purposes of comparison.

7. How on such an hypothesis can we explain the beds of limestone composed of or filled with fragments of *Eozoon*?

EXPLANATION OF PLATE IV.

FIG. 1.—Small specimen of *Eozoön*, separated from the matrix, and showing a turbinate form. Nat. size. Coll. Dawson.

FIG. 2.—Weathered specimen of *Eozoön*, showing a section through the middle, with two cylindrical, osculiform, vertical tubes. The modification of the laminæ at the sides of the tubes is similar to that at the exterior. Nat. size. Coll. Dawson.

II.—OBSERVATIONS ON THE ROUNDING OF PEBBLES BY ALPINE RIVERS, WITH A NOTE ON THEIR BEARING UPON THE ORIGIN OF THE BUNTER CONGLOMERATE.[1]

By PROF. T. G. BONNEY, D.Sc., LL.D., F.R.S., F.G.S.

WHEN preparing my address to Section C in 1886, I had much need of information as to the amount of rounding which takes place in rock fragments when transported by rapid streams. Useful information and references are given in Dr. A. Geikie's Text Book[2] and in De Lapparent's "Traité de Géologie,"[3] and there are the ex-

[1] A Paper read at the Meeting of the Brit. Assoc. (Section C) in Manchester, 1887.
[2] Book iii. pt. ii. sec. ii. [3] Book ii. sec. i. ch. iii.

perimental researches of Daubrée in his "Géologie Experimentale";[1] but from neither these nor other sources (so far as known to me) could I obtain what I wanted. I must, however, admit that I am less familiar with the talus heap of geological literature than I should be, and prefer making observations in the open air, to hunting for records of them in a library. So, as I had some opportunities of doing the former during my journey last summer, I record the results in the hope that they may be useful to others; first heartily thanking my companion, the Rev. E. Hill, for constant co-operation and assistance.

These observations may be arranged roughly in three groups, which correspond with the three stages in the physical history of an Alpine river. It begins as a series of torrents, born for the most part high up on the mountain side from snow-bed and glacier. Its next stage is that of a single torrent rushing over the bed of an Alpine valley, still bounded on either hand by mountain ranges; the third, and last for our present purpose, begins as it issues from the 'gates of the hills' and commences its journey through the lowland plains. In the first of these stages its fall is always rapid, as it leaps from ledge to ledge, or even from crag to crag, descending not unfrequently at average rates of 250 feet to 500 feet in a mile, or along slopes averaging from 3 to 6 degrees. Thus it is a rushing roaring cataract, able always to sweep along boulders full a couple of feet in diameter, and often much larger blocks. In the second stage the fall becomes more gentle, though occasionally, especially at the commencement, there may be a partial return to the former conditions; tributary streams also are being constantly received, which have only passed through that stage; but gradually as the valley widens the torrential character is lost, and the river flows as a strong swirling stream, in which intervals of actually broken water are rare. Lastly, after emerging from the mountains, and thus being cut off from all further contributions from torrents, it sweeps along with a strong steady flow, "hasteless but restless," perhaps one of the grandest representations of unobtrusive power that can be seen in Nature.

Obviously in observations of the present kind, little more than general results can be given. A river is constantly receiving tributaries, which discharge into it materials, not only differing in hardness or tenacity, but also in the amount of detrition which they have undergone. The strength also of its current varies from time to time. In some districts, or at certain seasons, what in the morning was a dry stream-bed, in the afternoon may be a roaring torrent. Further it is extremely difficult to determine the velocity with which a mountain torrent flows. In the case of some of the larger and less rapid rivers we made rough estimates by watching floating bits of wood and the like; they varied from about $2\frac{1}{4}$ to $4\frac{1}{2}$ miles an hour. An approximation also may be made from observing the size of the pebbles in the bed. A table is quoted in most text

[1] Vol. i. sec. ii. ch. i.

books which may be thus extended theoretically for pebbles formed of an average rock.

Diameter of pebbles just moved.	Velocity of stream.	
1 inch...............	2 feet per second,	1·3638 miles an hour.
2 inches	2·82 feet „	
3 „	3·46 „ „	
4 „	4·00 „ „	2·7276 „ „
5 „	4·47 „ „	
6 „	4·90 „ „	
7 „	5·29 „ „	
8 „	5·65 „ „	
9 „	6·00 „ „	4·0914 „ „

Hence we may infer that a deposit in which fairly well-rounded pebbles of about 4 inches diameter are so common as to be characteristic, is the result of a stream which flowed pretty steadily at a rate of about $2\frac{3}{4}$ miles an hour, and one in which they are about 8 inches or 9 inches diameter, is the result of a stream flowing about 4 miles an hour. It must, however, be remembered that this would be the velocity at the bottom of the stream, which is estimated at about half that of the surface in the middle. Great variability in the size of the pebbles, and especially the presence of frequent boulders or subangular blocks much exceeding the average size,—as, for example, a mixture of blocks something like two feet in diameter, with pebbles generally not more than one foot in diameter, and commonly less,—is indicative of torrential discharge.

For brevity I use the term 'Alpine rock' to mean gneisses, more or less granitoid, and mica-schists of various kinds, together with hornblendic or chloritic schists, and possibly serpentines—that is to say rocks, which are in all cases crystalline, and in some at least of igneous origin.

Group I.

Bed of Romanche above Villard d'Arêne (Dauphiné).—This stony plain lies at a height of about 5000 feet above the sea—at the foot of a steep descent of 1500 feet. The river is fed by streams from snow-beds and glaciers, and its sources may be roughly estimated as from 7000 to 8000 feet above the sea, and at distances of three to five miles[1] from the place of observation. The stones are chiefly granitoid rocks, but some are Jurassic mudstones (these are from near at hand). Leaving the latter out of consideration, the stones, which vary from boulders downwards, are generally subangular, even the smaller pebbles not being well rounded.

Bed of torrent through village at Windisch Matrei (Tyrol).—This comes down from the valley running up to the Kalser Thorl, and probably has descended some 2000 feet. The 'torrential' character is indicated not only by the variability in the size of the stones and boulders, but also by the high walls which protect the village from its ravages. Stones from 3 ins. to 6 ins. diameter were common; others up to about a foot diameter were fairly common, and larger occurred.

[1] Distances in this paper, unless otherwise stated, are measured on a map, and so are obviously less than the actual course of the stream.

Well-rounded pebbles rare, and never large. Alpine rock, including some serpentine.

Little plain at foot of Gross Venediger.—Enclosed by craggy mountains; stones brought down by various torrents, chiefly from snow-beds and glaciers, descending precipitously from 1000 to 2000 feet. Boulders and pebbles of Alpine rock, the latter not much rounded, having generally little more than the corners worn away; only some of the smaller and softer are moderately rounded.

Bed of Stilluphthal (Zillerthal).—Glaciers and snow-beds surround the head of the valley, the floor of which rises rather gradually. Deposits torrential in character. Alpine rock. Observation at 3500 feet, where the stream flowed with only a slightly broken surface. Stones subangular to imperfectly rounded, mostly 3 ins. to 4 ins. in diameter, a few nearly a foot. A couple of miles or so lower down, at a height of 2950 feet, the flow is more rapid: many pebbles 3 ins. to 4 ins. in diameter, varying from rounded subangular to subangular rounded, together with larger boulders of all sizes up to at least a yard diameter, some of which were moderately rounded; chiefly gneiss and granitoid rock.

Below Ginzling, Zillerthal.—Place of observation about 3230 feet: the river being formed by confluence of a torrent from the Floitenthal (a glen about nine miles long, enclosed by steep mountain walls, seamed by cascades and rising at the upper end from 9000 feet to 11,000 feet, and terminated by a rapid descent through a rocky gorge) and that from the Zemmthal (a valley perhaps three miles longer, which rises on the whole more gradually, and is enclosed by mountains somewhat lower). Materials, various Alpine rocks. All sizes up to about a foot in diameter common, but many exceed this; blocks up to two or three feet diameter not being rare: much variability in the amount of rounding, many being quite subangular, but some fairly well rounded,[1] these chiefly a rock resembling a tonalite not rich in quartz and a felspar-actinolite rock (rather rare). The former I believe occurs *in situ* far back in both these glens.

Group II.

We may commence by following the course of the river last described. At Mairhofen (2096 feet) by the Calvarienberg, stones commonly 4 ins. to 6 ins. diam., but both smaller and larger, are present; some blocks are quite a yard in diameter. Amount of wearing very variable; almost the only well-rounded pebbles are the above-named 'tonalite'; next to that is a porphyritic gneissoid rock, common in the Stilluphthal. Alpine rocks, with some subcrystalline limestone.

At Zell (four miles and a half and more than 200 feet lower down). Stream strong, surface rather broken in the swifter parts. Stones mostly from rounded subangular to fairly rounded, commonly from about 4 ins. to 6 ins. smaller of course occur, but rarely one over

[1] It must be remembered that when a torrent descends precipitously over a bed of rock, not a few stones may receive an exceptional amount of rounding by being whirled about in 'potholes.'

1 foot diameter. Mostly granitoid gneisses of a somewhat friable character.

I have in my note book observations of the Inn at Jenbach, Innsbruck, and near to Landeck, of the Isel between Windisch Matrei and Lienz, of the Drave at the latter place, of the Eisack near Brunecken, and at Bozen, of the Romanche at Vizille, and the Isère at Grenoble; but it is perhaps needless to quote them in detail, as to a great extent they would be repetitions of the above statements. Suffice it to say the stones commonly range from about 3 ins. to 6 ins., smaller and larger occurring, in the latter case not seldom up to nearly 1 foot, with occasional large boulders; that the amount of rounding is variable, but the majority of the first named may be described as from subangular to moderately rounded—well-rounded pebbles being generally not common.[1] Materials, Alpine rocks with variable amounts of limestones and grits. At Bozen also the igneous rocks of the district were well represented.

Group III.

The first case examined was the Po at Turin. The river and its tributaries have now flowed over about 35 to full 50 miles of plain. The principal streams which feed it descend valleys from about 15 to over 30 miles long, and may be reckoned as having their sources at from 5000 to 6000 feet above the sea.[2]

The stones exposed near the banks consist chiefly of Alpine rocks, are commonly 3 ins. to 4 ins. diameter, occasionally running up to about 8 ins. together of course with smaller. As a rule they are not well rounded, retaining more or less a subangular outline, though the corners and edges are worn off.

In travelling from Turin to Milan, and thence to the Lago di Garda, several rivers are crossed, and sections obtained of the substratum of the great alluvial plain of Piedmont and Lombardy. The results in regard to the former may be summarized in a tabular form.

Name.	Approximate length of river.		Diameter of Pebbles.		Condition.
	Among the Mts.	Over the plain.	Average.	Maximum.	
Stura ...	18 miles.	20 miles.	3″ to 4″	? 6″	Often fairly rounded, but many still subangular.
Orco......	22 ,,	18 ,,	abt. 4″	6″	Fairly well rounded.
Sesia ...	25 ,,	35 ,,	abt. 2″	rarely > 4″	Moderately ,,
Ticino ...	...	20 ,,	3″ to 4″	?	,, ,,
Adda ...	...	20 ,,	3″ to 4″	? 6″	Fairly well ,,

The main streams of the Ticino and Adda have most of their Alpine pebbles stopped by the Lakes of Maggiore and Como, but

[1] Our estimates of the rates of flow varied from about three to four and three-quarter miles an hour. I expect these great mountain rivers run at an average pace of nearly four miles an hour, and at certain seasons considerably exceed this.

[2] I mean as fairly strong streams; in some cases brooklets would be higher, and of course the snow-beds about the sources of the Po rise up in places to quite 9000 feet.

they receive some sub-Alpine tributaries. Consequently, limestone pebbles characterize their gravels.

Besides these observations we repeatedly had indications of the gravel of the great plain, either from the stones scattered over the fields, from ballast pits, or from railway cuttings. Here also pebbles often about 3 ins. or 4 ins. are common, with occasional larger ones. In fact, they frequently are very similar in size to those of the Bunter Conglomerate in Staffordshire, but generally not quite so well rounded. Limestone becomes more common, as might be expected, as we proceed eastwards. This remark holds, I believe, of the great plain of Lombardy as far as the south end of the Lake of Garda.

Old drifts, repeatedly seen between Lyons and Grenoble, in size, amount of rolling and arrangement, bore a remarkable resemblance to the Bunter pebble-beds of Staffordshire (except that the materials were mainly limestone). This was particularly the case near Vireucal, where the section was some 50 feet high, and the pebbles were parted by streaks or bands of sand. The old drifts of the Rhine at Stein and near Bale are very similar.

In regard to the Lake of Garda, I endeavoured to ascertain the action of its waves on the beach pebbles. These are abundant to the east of Desenzano, and they have evidently been derived from the north. They are fairly well rounded, but seeing that similar pebbles, about as well rounded, occur in the drifts of which its banks consist, no inference can be drawn from them. But I observed that well-rounded pebbles had been formed on the shore from fragments of a soft red brick; also that shards of ordinary red earthenware had been sometimes fairly well rounded. It must be remembered that the Lago di Garda is noted of old for its waves, "fluctibus et fremitu assurgens, Benace, marino;" but, as a rule, the great sub-Alpine lakes have not, so far as I have noticed, much effect on rock fragments.

It is difficult to give precise statements of the amount of fall in the Alpine rivers; but the following are rough approximations, calculated from the heights quoted in guide-books, which of course do not give the exact level of the river at the place, and from the distances by road, which, at any rate when the valley is tolerably level, are generally rather sometimes considerably shorter than the river course.

The Inn, from St. Moritz to Samaden (three miles) falls about 65·3 feet per mile; from Samaden to Landeck (79½ miles) about 37·3 feet per mile; from Landeck to Innsbruck (52¾ miles) about 13·8 feet per mile; from Innsbruck to Jenbach (23 miles) 3·8 feet per mile (I believe rather more, for I think the height given for Jenbach is above the Inn—possibly 80 or 100 feet too great).

The Ziller from Ginzling to Mairhofen (about 7¼ miles) falls 155·5 feet per mile; from Mairhofen to Zell (4½ miles) 17·8 feet per mile; from Zell to Jenbach about 4·6 feet or a little more (this, for the above reason, and as the embouchure of the Ziller is not at Jenbach itself, is a very rough estimate).

The Isel (including a tributary): Tauern Haus to Windisch Matrei (about 10½ miles) about 164 feet per mile; Windisch Matrei to Lienz (18 miles) 58 feet per mile.

It is very difficult to estimate the fall in the Po and its tributaries. Turin is 602 feet above the sea, probably the edge of the plain is about 800 feet. That would give a fall of about 4 feet per mile. In the tributary valleys I should think that the fall would be not less than 100 feet per mile. As an example of a true torrent, the Reuss between Andermatt and Amsteg falls about 212 feet per mile; from the latter place to the Lake of Lucerne only 26·3 feet per mile.

The facts thus collected appear to me to warrant the following conclusions:—

1. The rapidity with which a pebble is formed depends *cæteris paribus* on the nature of the rock.

2. Pebbles are rounded with comparative rapidity when the descent is rapid; that is, when they are dashed down rock slopes by a roaring torrent, capable of sweeping along blocks of far greater size.

3. Pebbles are rounded with comparative slowness when the descent is gentle, and the average pace of the river is just about able to push them along its bed.

4. As indicated by Daubrée's interesting experiments, the process of rounding *cæteris paribus* always goes on more rapidly at first.

In the above observations the rocks (with the exception of some vein-quartz which generally proved a rather intractable material) may be taken as ranging in hardness from rather above 3 to about 6. The limestone pebbles would probably range from 3 to 4, and there would be chemical action in addition. The Alpine rocks, as a rule, would probably range from 5 to 6, for though quartz is present, there is always a good amount of felspar or mica. The easy rounding of the more micaceous schists, due to their softness, is to some extent counteracted by their fissility.

If, then, we find in any conglomerate, a large number of well-rounded pebbles of a rock not less hard than felspar, we are justified in concluding that they are the deposit of a river which, in any case, has had a course of several miles, and has either descended as a very rapid stream from snow-capped mountains of considerable elevation, the detritus, in short, of a strong, full, torrent in a valley running down from a great mountain-chain, or of a river which, rising at a more moderate elevation and swollen by many tributaries, has flowed for a very much longer distance. Perhaps we might venture to say, as a rough standard of comparison, that the effect of a thousand feet of rapid descent is equivalent to that of the more leisurely traverse of at least twenty miles, so that fairly well rounded pebbles of a rock with hardness not exceeding 6 signify at least either a rapid descent of three thousand feet or a journey at a less speed of sixty miles.[1]

[1] Prof. Daubrée (Géol. Experim. vol. i. sec. ii. ch. v.) obtained experimentally a distance of a little less than 16 miles for the manufacture of a rounded pebble of granite, but this must be regarded as the least possible distance, for in his experiments the fragments would be knocked one against another much more than in transport by a stream, except perhaps in a "pothole."

If then we consider the question of the origin of the Bunter pebbles in the light of these facts, two suggestions as to their origin are at once shown to be impossible. The majority of the pebbles are a very hard quartzite, are from 2 ins. to 4 ins. diameter, and are well rounded. Hence they must have had a much longer descent or a much longer journey than that above named.

By one author they have been referred to a concealed ridge of Palæozoic rock in Eastern England,[1] by another to a similar ridge in Central England, of which the Malvern and Lickey Hills, etc., are the monumental outcrops.[2] I have already pointed out the difficulties attending both these views, so far as regards the nature of the materials, their enormous volume and their disposition. I have commented on the confused views of the latter author, both as to lithology and physical geology; but the observations above made effectually dispose of one of his criticisms, that pebbles coming from Scotland would have been "reduced to sand" before reaching Staffordshire,—a criticism indeed which even the knowledge in our possession at that time did not justify. They also indicate that unless we maintain the Bunter Beds to be a marine deposit (which I do not suppose will find any support with modern geologists), its pebbles can only have been formed by strong and full rivers. These, if from insular lands, must have issued from lofty mountains; if from continental, must have flowed with strong stream for long distances. Considering the hardness of the materials, we may demand insular mountains even higher than the Alps, or rivers with courses exceeding a couple of hundred miles in length, of fuller volume and stronger stream than now exist in Britain. The sources for the Bunter pebbles then, proposed by either of these authors, Utopian at best, cannot be made to accord with the facts which I have recounted, while the general resemblance of the Bunter Beds to the conglomerate of the Nagelflue, and to the gravel of the plains which stretch away from the feet of the Alps, renders the northern origin of these pebbles,—where continental conditions did prevail and identical pebbles still exist in older conglomerates—a far more probable theory.

III.—The Gneissose Granite of the Himalayas.

By Colonel C. A. McMahon, F.G.S.

I HAVE read with great pleasure Mr. R. D. Oldham's interesting article in this Magazine, for October, 1887, on the gneissose rocks of the Himalayas. Mr. Oldham concurs with me in assigning an eruptive origin for the more or less gneissose rocks at Dalhousie, the Chor, and for almost all those in the Satlej Valley; and as I have in my published papers expressly intimated "my belief that some of the crystalline rocks of the north-western Himalayas are metamorphic gneisses" (Records Geol. Surv. India, vol. xviii. p. 110), I see no grounds for dissenting from his observations regarding the latter class of rocks.

[1] Geol. Mag. Dec. II. Vol. X. p. 285.

[2] Proc, Phil, Soc. Birmingham, vol. iii. p. 157; Geol. Mag. Dec. II. Vol. X. p. 199. This locality is practically included in the other.

One remark, however, in Mr. Oldham's article, tempts me to offer a few words of explanation in continuation of my last paper in the Geological Magazine. Speaking of the gneissose-granite, Mr. Oldham expresses his belief "that the very slight foliation of the larger masses is principally a fluxion structure, while the more developed structure of the thinner bands, and near the margins of the larger masses, was produced in the solid but *still heated granite* [the italics are mine] by the same causes—whatever they be—that led to the foliation of the adjacent sedimentary beds;" and in a footnote he remarks; "In 1884 Colonel McMahon seems to have held an opinion somewhat similar to this (see Records Geol. Surv. India, vol. xvii. p. 72), but so far as I can understand his paper in the May Number of this Magazine, he has now abandoned it."

I hoped that I had made my meaning sufficiently clear; but as this does not appear to have been the case, a few explanatory remarks may not be out of place. The passage in my paper published in the Records Geol. Surv. India referred to runs as follows:—"The conclusion at which I have arrived, on a consideration of all the facts of the case, is that the invasion of previously metamorphosed strata by gneissose granite, combined with the pseudo-foliation of the latter due to the pressure of hard strata on a partially cooled and imperfectly viscid rock, has imparted to the intruded rock the superficial appearance of being a member of the same metamorphic series as the schists and slates into which it has intruded. There is no inconsistency, I would point out in conclusion, in supposing that the rock which gives evidence of having passed through a stage of aqueo-igneous fusion was partially cooled and semi-viscid when[1] actually intruded into the schists. Observation in our own time shows that there are pauses and long intervals in volcanic action; and doubtless similar pauses took place in plutonic action during which the cooling and partial consolidation of igneous masses went on and the larger porphyritic crystals found in many of them were formed. The subsequent motion of a partially consolidated viscid rock and its intrusion as a sheet between hard strata, or between the walls of a fault, would, it seems to me, naturally produce parallelism of structure, or pseudo-foliation, as long ago pointed out by Scrope and Naumann."

I have not gone back one iota from the view expressed in the above extract, and I am at a loss to understand why I should have been supposed to have done so. The observations given at pp. 219, 220, of the 1887 volume of this Magazine, seem to me to be merely a detailed explanation of the view more briefly expressed in the above extract. In the latter three conditions are noted; the partial consolidation of the granite before it was moved into place, traction action on the granite when it was squeezed into position; and the "pressure of hard strata" upon the intruded mass.

That partial consolidation had set in before the granite was moved into its present position seems implied by the pronounced porphyritic character of the rock. "All the facts connected with

[1] In the Records the word is *where*—a senseless alteration of the text due to the Indian printer's devil.

these porphyritic lavas," writes Professor Judd with reference to a somewhat different class of rock in his well-known work on Volcanoes, p. 256, "points to the conclusion that while the crystals in their ground-mass have separated from the liquefied materials near the surface, the large embedded crystals have floated up from great depths within the earth's crust, where they had originally formed." I do not mean to affirm that a similar inference would be safe in respect of all porphyritic rocks, plutonic as well as volcanic; but I think we may safely draw that inference with regard to the porphyritic crystals in the Dalhousie rock, for in some places tongues, and veins, intruded into the adjacent schists are as distinctly porphyritic as the main mass of the granite (Records Geol. Surv. India, vol. xv. p. 45), and I do not think any one would allege that the large porphyritic crystals in the small veins were formed *in situ.* The same conclusion must, I think, be arrived at when large porphyritic crystals are found (Records Geol. Surv. India, vol. xvi. p. 129) in a matrix so fine grained that the Dalhousie rock occasionally assumes the superficial appearance of a felspar porphyry.

That the granite was, at the time of intrusion, partially cooled and imperfectly viscid, is almost conclusively proved by the condition of the foreign fragments included in it. At page 175 of the volume to which Mr. Oldham has referred (vol. xvii. of 1884) I wrote as follows:—"In the case of the long splinter of schist, a fragment of which is depicted in the plate attached to this paper, it is clear that it must have been included in the granite when the latter was already partially consolidated, and had lost a considerable part of its heat. I have found on other grounds, in my previous papers, that the gneissose-granite had partially consolidated before it was intruded into the stratified rocks; and the evidence afforded by the fragment of schist under consideration confirms this conclusion. The schist would not have retained its fine foliation had the granite been in a fluid state, and at the high heat indicated by that condition." The reasons for coming to this conclusion are given in detail in my paper.

I may note in passing that the texture of the porphyritic granite immediately round the fragment of schist referred to is fairly granitic, and this fragment proves that the rock from which it was torn was in a foliated condition before the intrusion of the granite took place. The granitic structure of the granite compared with the fine foliation of the schist, a point that is well brought out by the heliogravure reproduction of a photograph given at p. 175, vol. xvii. Records Geol. Surv. India, appears to negative the assumption that the foliation of the Dalhousie granite and the foliation of the schists into, and through which, it was intruded, are both alike due to pressure-metamorphism operating *after* the intrusion of the granite.

From the use of the words "still heated granite," and from the context, I am under the impression that Mr. Oldham is of opinion that the structural changes in the granite which resulted in foliation were produced before it had perfectly cooled down after its injection; if so, our views seem to be substantially identical.

Whether he holds that the granite was injected in a fluid, or in a partially consolidated condition, is not so clear to me. Possibly if there is any apparent divergence in our views, it may be owing to my not having expressed mine in sufficient detail.

Mr. Oldham, in the extract I have quoted, speaks of the condition of the granite when foliation was produced as "*solid* but still heated." (The italics are mine.) In my papers I have avoided the use of the word solid, and preferred to speak of the granite as being in "a partially cooled and imperfectly viscid" condition, or as an "imperfectly consolidated" mass; but by the use of these expressions I contemplated a considerable advance towards solidity. In my article in the May, 1887, number of this MAGAZINE, I stated that the "semi-plastic mass was subjected to enormous pressure; the mica was crumpled, and the crystals of felspar were cracked and ruptured." These results, I need hardly say, could not have been produced unless the solidification of those portions of the rock in which they are to be observed was in a somewhat advanced stage. But, on the other hand, I do not think it necessary to hold that the granite at the moment of intrusion was everywhere in a state of maximum viscidity. Its condition, I apprehend, varied from point to point; being in some places in the normal condition of a liquefied granite, whilst at others it was almost completely made up of minerals that had already crystallized out of the magma. There were also, we may suppose, numerous gradations between these two conditions. That this was actually the state of the granite I infer from the examination of thin slices under the microscope, and from the appearance of the rock in the field. In some places it is a perfect granite—in others it is a perfect schist. In specimens from some spots the microscope reveals the marks of crushing; in those from other localities these marks are absent.

At pages 76–77 of the February, 1887, number of this MAGAZINE, I have suggested a few reasons to account for a similar state of things in the Lizard gabbro. The rapid, and often apparently capricious, passage of rocks of this class from a granitic to a foliated condition, suggests very complex questions which cannot be discussed in detail on the present occasion; but though I shall not now attempt to explain at length why traction, shear, and pressure, operating on an imperfectly consolidated eruptive rock, fail to produce perfectly uniform results in every portion of the erupted mass, still, it may be as well to briefly allude to some of the causes which, in my opinion, may have produced these results in the Dalhousie granite. One reason has already been alluded to, namely, the want of uniformity in the consistency of all portions of the erupted mass at the moment of eruption. Micro-petrologists are already familiar with the idea that a more or less complete liquefaction of deep-seated igneous rocks takes place when the pressure under which they have been held is relaxed by portions of these rocks finding a vent at the surface;—instance the partial refusion of the porphyritic quartz crystals in quartz porphyries. The order in which minerals fuse, or crystallize, depends, to mention one factor

only, on pressure; and, in the case of the Himalayan gneissose-granite, pressure must have varied considerably from point to point within the area of eruption.

The high probability that the rising granite varied in its consistency in different portions of its mass at the time of intrusion must not be lost sight of in dealing with a rock that occurs within an area that extends not for hundreds of feet, or hundreds of yards even, but for hundreds of miles.

If other causes besides the absence of perfect homogeneity at the time of intrusion are wanted to account for the variation of structure to be observed in the rock, the following may be mentioned:—At the points where shearing was most severe, secondary heat was probably developed, and the resulting chemical and mineralogical action may have been considerable. Then, again, we cannot suppose that the earth-movements that produced the contortion, overfolding, and faulting of the strata were sudden and explosive in their character; doubtless they were due to long-sustained compression, and the movements that resulted from this compression were repeated—possibly with considerable rests, or intervals between—during long periods of time. Each of these movements probably left its mark upon the rocks, and who is now to discriminate between the effects of the shear, traction, and pressure that accompanied the actual act of intrusion, and the shear and pressure caused by the earth-movements that must, in many cases, have followed the act of injection and have sheared and nipped the gradually cooling granite with a pressure that not only varied locally from place to place, but was applied again and again *during successive stages of consolidation?*

When I penned the article which appeared in your May, 1887, Number, the object I had chiefly in view was to show that the foliation of the granite of the N.W. Himalayas was due to pressure acting on an imperfectly consolidated intrusive rock prior to its complete consolidation, and that it was not due to pressure-metamorphism exerted on a solid and cooled rock after it had attained a consolidated and crystalline condition. In short, that it was an incident in the history of the eruption, and was not, like cleavage, due to pressure exerted on a solid rock. The theory of pressure-metamorphism differs materially from the explanation I have advocated to account for the foliation of the granite of the N.W. Himalayas. The former is not concerned with a phase of the consolidation of an eruptive rock. Pressure-metamorphism may come into action whole geological ages after the last stage of the intrusion of an igneous rock has come to an end; and may operate on rocks of purely sedimentary origin. Whether or not pressure-metamorphism applied to solid rocks is capable of producing all the results alleged by the extreme advocates of the theory, is a question foreign to the present inquiry. All that I have contended for is, that, in the regions embraced by my papers, pressure applied to the granite *after* its complete consolidation was not the cause of its foliation, but rather pressure applied whilst it was yet in a more or less plastic condition.

IV.—On the Mineralogical Constitution of Calcareous Organisms.[1]

By Vaughan Cornish and Percy F. Kendall,
Berkeley Fellow of the Owens College.

Introduction.

IN Mr. Sorby's presidential address at the anniversary meeting of the Geological Society in 1879, attention was drawn to the fact that the carbonate of lime in calcareous organisms is in certain cases in the form of calcite, in others of aragonite, and various genera of such organisms were classed according to their mineralogical constitution. It was also shown that aragonite fossils are of greatly inferior stability to those formed of calcite, in many deposits casts only of aragonite fossils being preserved, whilst those of calcite remain unaltered. In the same address Mr. Sorby insisted on the importance of this difference of stability as affecting the trustworthiness of the geological record.

The idea that the disappearance of aragonite fossils is due to the action of carbonated water naturally suggests itself; at the same time no experimental data appeared to exist which would lead one to suppose that calcite would be acted upon less readily than aragonite by a solution of carbonic acid.

Part I. of the present paper contains *an account of the experimental evidence obtained as to the cause of the inferior stability of aragonite fossils as compared with those formed of calcite, with observations on the geological conditions favourable to the removal of aragonite fossils.*

It was pointed out by one of us in a paper in the Geological Magazine, Nov. 1883, that *those shells classed by Mr. Sorby as calcite are characterized in the fossil state by a compact texture and by translucency, whilst the aragonite shells are opaque and of a chalky appearance,* and the opinion was there stated that these characters would be found sufficiently constant to be of use in determining the zoological position of obscure forms.

Part II. of the present paper contains *an account of the work done in following out the above observation, and in the examination of certain organisms belonging to groups not yet classified according to their mineralogical constitution.*

Part I.

Two fossil shells, *Pecten opercularis* (calcite) and *Pectunculus glycimeris* (aragonite) were selected, not differing greatly in weight, and presenting nearly the same extent of surface. The aragonite shell was a specimen entirely unacted on, with a hard compact surface. These shells were suspended in a solution of carbonic acid, removed from time to time, weighed, and then placed in a fresh solution of carbonic acid. The experiment was only discontinued when the aragonite shell fell into fragments.

[1] An Abstract of this paper was read before Section C. of the British Association at Manchester, September, 1887.

Three circumstances were noted, viz.:

1. That the calcite shell lost in weight through solution of its substance, but retained its compact texture and translucency, so that no alteration in appearance could be observed till it had lost a large percentage of its substance.

2. That the aragonite shell lost by solution between two and three times as great a percentage of its weight as was lost by the calcite shell.

3. That the hard compact surface of the aragonite shell speedily disappeared, the shell assuming a consistency similar to that of kaolin, and falling into fragments after losing 60 per cent. of its weight by solution.

Experiments with other aragonite shells showed that after a short period of subjection to carbonic acid solution they are reduced to a consistency such that the substance of the shell comes away with a touch, and such that a gentle stream of water is sufficient entirely to disintegrate the shell. Calcite shells, on the other hand, after being acted upon lose only a small quantity of substance by washing. In the Coralline Crag we have observed them in a pulverulent state only in those portions from which the aragonite shells have been entirely removed.

From observations 2 and 3 it follows that carbonated water acts so as to decompose aragonite fossils more readily than those formed of calcite, and from 3 it further follows that where water is free to circulate, the aragonite fossils already acted upon lose their coherence and are reduced to the condition of a powder.

In addition we see from 1 that the retention of their compact structure and translucency by calcite fossils lends to them an appearance of immunity from the action of carbonic acid which they do not in reality enjoy.

It remained to investigate the cause or causes of observation 2, and to ascertain whether the fact observed, viz. that aragonite shells are dissolved far more rapidly than the calcite, is due (*a*) to difference of mineralogical constitution; (*b*) to difference of structure of the shell related to that difference of mineralogical constitution; or (*c*) to both causes combined.

To test the first point we placed pure crystalline calcite and aragonite in fine powder in two flasks of the same capacity and shape together with equal volumes of carbonic acid solution of equal strength, and determined the loss of weight suffered by the substances after the lapse of an equal interval of time in each case.

The result of the experiment showed no excess of action on the aragonite over that on the calcite.

A similar experiment where finely powdered fossil calcite and aragonite shells were employed gave similar results.

The conditions under which these determinations were made were not such as to eliminate certain possible sources of error, but the degree of accuracy obtainable is sufficient to justify us in concluding from the numbers given below that the more rapid solution of aragonite fossil shells is not due directly to difference of mineralogical constitution, but to difference of structure.

In the case of the experiment where the fossil shells were suspended in carbonated water the percentage of loss is calculated on the weight of the shell before its immersion in the carbonic acid solution in each case, and not on the original weight. It will be observed from the numbers given that the ratio between the losses by solution increases towards the end of the experiment when the aragonite shell had assumed a clayey consistency.

Experiment with fossil shells suspended in CO_2 solution:—

Nature of Subst.	Original Wt.		Loss after 70 hrs.		After other 48 hrs.		After other 74 hrs.
Calcite	·3196 grams.	...	12·60 %	...	7·12 %	...	9·44 %
Aragonite...	·3779 „	...	26·35 %	...	17·18 %	...	27·13 %

Experiment with fossil shells in a state of fine powder:—

Nature of Subst.	Original Wt.		Loss in Wt.		% of Loss on Original Wt.
Calcite	·5694 grams.	...	·0829 grams.	...	14·56
Aragonite ...	·6010 „	...	·0858 „	...	14·27

Experiment with powdered crystals:—

Nature of Subst.	Original Wt.		Loss in Wt.		% of Loss on Original Wt.
Calcite	·5850 grams.	...	·0404 grams.	...	6·90
Aragonite ...	·6170 „	...	·0350 „	...	5·65

With regard to the question of structure, aragonite fossil shells have a hard surface, but the interior, though close-grained, is porous. The calcite shells on the other hand are compact throughout. The porosity of the aragonite fossils is indicated by the circumstance that they adhere to the tongue. The difference of structure is well shown by the following experiments. If a fossil calcite shell be immersed in water a few large bubbles collect on the shell, and after a time detach themselves one by one. On the other hand, if an aragonite fossil from which the hard outer layer has been removed be immersed, a stream of small bubbles rises rapidly from the shell, giving an appearance of effervescence similar to that produced by the action of a dilute acid on carbonate of lime.

The geological conditions favourable to the removal of aragonite shells appear to be:

(*a*) Enclosure in permeable beds.

(*b*) *Flow* of carbonated water.

The latter condition can of course be best complied with above the saturation level of the rock. This is well illustrated by the following observation made at the Coralline Crag pit belonging to Mr. Pettit, on the Leiston road, near Aldborough, referred to in the paper already cited (GEOL. MAG. Nov. 1883). Here, above the saturation level, aragonite shells have entirely disappeared, casts alone remaining, whilst below the saturation level, in a shallow excavation made in the corner of a small pond, a bed of hard Crag was met with containing actual aragonite shells, though in so advanced a stage of decomposition that it was impossible to secure a specimen. It is interesting to observe that where well-marked lines of flow occurred, even the calcite shells were entirely removed.

In the same connection we may quote from Mr. Sorby's address

a passage which has reference to the Portland Oolite. It will be noticed that Mr. Sorby's conjectures are borne out in detail by our experiments. The passage is as follows: "Where the deposit has taken place in a current, they (the aragonite shells) are more or less completely absent, probably because they had become tender by decomposition and were broken up before final deposition. Under similar circumstances the calcite shells have resisted complete disintegration and still show the original structure."

At Walton-on-the-Naze the uppermost beds of fossiliferous Red Crag contain very few calcite shells and immense numbers of aragonite shells. The latter are as a rule greatly decorticated and often quite pulverulent. The overlying bed formerly referred to as "Unproductive Sands" does not as a rule contain any shells, but thin lenticular patches of greatly decomposed fragments of shells occur, the species of which could sometimes, though rarely, be determined. This, and the circumstance that locally pipes of unproductive sand descend into the fossiliferous beds below, show conclusively that this was a case of decalcification. A prior observation by Mr. Whitaker (Q.J.G.S. vol. xxxiii.) led him to the same conclusion.

In a Coralline Crag-pit opposite Mr. Chaplin's farm-house on the road from Dullingham to Sudbourne, very loose sand containing only decomposed calcite shells can be seen to pass up into a loose sandy bed destitute of fossils.

Near Sudbourne Church a similar sand occurs, which can be recognised as decalcified crag, by the circumstance that a large percentage of the sand grains are coprolitic, a character which distinguishes the Red and Coralline Crag from all other deposits.

In the classical pit in Sudbourne Church Walks (Mrs. Rackham's), where the superposition of Red upon Coralline Crag can be observed, the Coralline Crag has suffered the removal of its aragonite shells, while the overlying Red Crag contains a profusion of organisms of aragonite constitution, a fact which appears to indicate that, previously to the deposition of the Red, the Coralline Crag had stood above the sea-level and had undergone submergence.

Part II.

As stated by Mr. Sorby, the true mineralogical character of any calcareous organism is best indicated by the specific gravity. This was determined by Mr. Sorby from the powdered substance. We were desirous, however, to ascertain if the destruction of the specimens could be avoided; and the following numbers from our determinations by the method of suspension show that in many cases at least it is not necessary to sacrifice the specimen. In the case of univalve shells, however, it is sometimes necessary to break into the whorls. Where a recent specimen has a thick epidermis, this must be removed by caustic soda.

The observations which follow were made in following out the indications obtained:—1. from the known inferior stability of aragonite fossils; 2. from the rule which appeared to hold with regard

to the translucency of calcite fossils and the opacity of those of aragonite.

Nature of Specimen.	Weight of Specimen.	Sp. gr.
Crystal of aragonite hexagonal (twin form)	37·3560 grams	2·933
Aragonite, fibrous variety	23·5111 ,,	2·857
Artemis lentiformis (fossil, opaque)	4·7490 ,,	2·840
Pectunculus glycimeris (recent)	3·9445 ,,	2·845
Calcite (cleavage rhombohedron)	3·0272 ,,	2·715
Pecten opercularis (fossil, translucent)	1·8711 ,,	2·70
Pecten opercularis (recent)	1·1116 ,,	2·70

Gasteropoda.

Scalaria, to which reference was made in the paper before quoted, proves to be calcite, as suggested from its translucency and mode of occurrence in the Coralline Crag. Its specific gravity is 2·685.

Murex tortuosus has a thick opaque inner layer, while the investment constituting the frills or varices is translucent. The specific gravity 2·85 indicates that the greater part of the shell is aragonite, as suggested by its appearance.

We are disposed to regard these features as valuable in the determination of the true affinities of the so-called *Purpura tetragona*, regarding which the late Dr. Jeffreys and Mr. Searles V. Wood jun., were at issue. *Purpura* as typified by *P. lapillus* has an extremely thin opaque layer, which does not reach the edge of the outer lip, and the specific gravity corresponds with that of calcite shells. *P. tetragona* on the other hand is opaque, with a translucent layer so insignificant in thickness that it is removed by attrition from all the prominences. The translucent layer is not visible within the outer lip.

The affinities of *P. tetragona* are therefore probably with *Murex arenaceus* rather than with *P. lapillus*.

Tectura testudinaria. Sp. gr. of recent specimen 2·834. In the fossil state it is opaque, with a translucent outer layer, hence we may conclude that, as in the case of *M. tortuosus*, the inner layer is aragonite and the outer calcite.

Fusus.

This genus furnishes evidence, which we consider to be conclusive, respecting the determination of the constitution of calcareous shells by their opacity or translucency in the fossil state.

Mr. Sorby stated in his address that the inner layer of *Fusus*, as typified by *F. antiquus*, is aragonite, the outer calcite, and in the paper by one of us already cited it was mentioned that the inner layer was opaque and the outer translucent, and several fossil species were instanced, which, being entirely opaque, were probably wholly aragonite. The sp. gr. of three species which have been determined by us shows them to be wholly aragonite. We give the sp. gr. of *F. antiquus* for comparison.

F. antiquus	sp. gr.	2·668 (very thin aragonite layer)
F. costifer	,,	2·88
F. pyriformis	,,	2·95
F. longævus	,,	2·89

The exceptionally high sp. gr. of *F. pyriformis* is no doubt to be accounted for by the fact that the specimen was impregnated with oxide of iron.

Cephalopoda.

Ammonites.—From the mode of occurrence of these shells, the circumstance that in porous beds casts only are preserved, and the similarity in appearance of the shells to those of *Nautilus* (determined by Mr. Sorby to be aragonite), we are justified in assigning them to the aragonite division.

The *Aptychi*, however, have the translucency characteristic of calcite, and they are found well preserved in beds such as the Chalk, in which the Ammonites are only represented by casts. The determination of the sp. gr. 2·70 shows them to be calcite.

Belemnites.—We find in Woodward's Manual of Conchology, p. 173, that according to the determination of Mr. Alex. Williams, the sp. gr. of the guard of *Belemnites puzosianus* is 2·674, and that of *Belemnitella mucronata* 2·677; they are therefore calcite, as their translucent appearance, familiar to all geologists, would lead one to suppose.

The phragmacone of *Belemnitella* is not known, and as no aragonite shells are preserved in the Upper Chalk, we were led to believe that the phragmacones of Belemnites would prove to be aragonite. Mr. Robert Etheridge kindly furnished us with a specimen in which the chambers were filled with translucent calcite, while the septa and the siphuncle which were preserved presented the usual chalky appearance of aragonite. The specific gravity was found to be 2·75, justifying the belief that a small quantity of aragonite was present, with the greater certainty that the appearance of the specimen shows it to be free from oxide of iron, and the mode of deposition of the calcite in the chambers, together with its high degree of translucency, furnish guarantees of its purity. A specimen of *B. minimus* from the Gault has the phragmacone preserved, and it presents the appearance characteristic of aragonite. It may be of interest here to note that the homologous structure of sepia has been determined by Sorby to be aragonite.

Polyplacophora.

Chiton (recent), sp. gr. 2·848, therefore aragonite.

Heteropoda.

Dolabella (recent), sp. gr. 2·859, therefore aragonite.

Lamellibranchiata.

Pecten opercularis (recent), sp. gr. 2·70, therefore calcite.

Pectunculus glycimeris (recent), sp. gr. 2·845, therefore aragonite.

Artemis lentiformis (fossil), sp. gr. 2·84, therefore aragonite.

Teredo Norvegica.—*Teredo* is regarded by Dr. Sorby as a typical calcite shell: but certain tubular fossils found by one of us in the Crag, and which have been regarded as *T. Norvegica*, have the opacity characteristic of aragonite; and upon this circumstance and peculiarities in its mode of occurrence the opinion was based that the

reference of the form to *Teredo* had been erroneous. In this view the late Dr. Gwyn Jeffreys concurred. The fossil has a sp. gr. of 2·9, and is therefore composed of aragonite. We offer no suggestion as to its affinities.

Hexacoralla.

All those corals examined by Mr. Sorby consisted entirely or almost entirely of aragonite.

Parasmilia centralis.—The circumstances of the preservation of this coral in the Upper Chalk induced us to examine it, when we found that it was translucent, and therefore probably calcite. This conclusion is confirmed by the sp. gr. 2·70.

Polyzoa.

Mr. Sorby observes that many Polyzoa have a specific gravity intermediate between those of calcite and aragonite, and suggests that they may be composed of a *mixture* of calcite and aragonite. Observations by one of us on Polyzoa show that these two substances, as indicated by the translucency and opacity, are not actually intermingled, but, as we have found to be invariably the case in other organisms, occur as two distinct layers, inasmuch as many genera, such as *Eschara*, have, when well preserved, an outer opaque and an inner translucent layer, the former being absent in deposits from which the aragonite shells have disappeared. Here the disposition of the layers is the reverse of what is found in the Mollusca, which always have the aragonite layer internal.

Foraminifera.

Mr. Sorby has ascertained that certain of these (genera not specified) are composed of calcite, but the facts we have accumulated regarding the group show that one great family, the Porcellanea, is similar in occurrence and behaviour to those structures characterized by the possession of aragonite tests. Moreover, the aspects of the tests, which have suggested the names *Vitrea* and *Porcellanea*, are as well shown in the fossil as in the recent state, and agree exactly with the aspect of calcite and aragonite shells respectively. Although we have not yet direct experimental proof that the *Porcellanea* consist of aragonite, yet it will be seen from what follows that they have been shown to be, relatively to the *Vitrea*, unstable towards the action of carbonated water.

The form called *Biloculina ringens* occurs along with aragonite shells in the Coralline Crag of Gedgrave, and is the most abundant Foraminifer in that deposit; but at Aldeburgh, Iken, Sudbourne Cross Roads (Mrs. Sewell's Pit), and the White Gates Pit, Sudbourne Park (in the Coralline Crag from which the aragonite shells have been removed), there is not a trace of it; while the *Polymorphina frondiformis*, comparatively rare at Gedgrave, is found here well preserved.

In Prof. King's "Monograph on the Permian Fossils" (Palæont. Soc. vol. ii.) it is stated that no Imperforata Foraminifera are known from any formation below the Trias; but the most striking evidence

of the instability of *Porcellanea* is furnished by the list of Chalk Foraminifera in Dixon's "Geology of Sussex," of which an analysis is subjoined.

CHALK FORAMINIFERA.

Miliola, sp. rare.	*Porcellanea.*
Lituolidæ, 4 spp.	*Arenacea.*
Lagenidæ, 49 spp.	*Vitrea.*
Polymorphinidæ, 4 spp. and vars.	,,
Buliminidæ, 13 spp.	,,
Textularidæ, 16 spp.	,,
Globigerina, 6 spp.	,,
Rotalina	,,

The significant fact appears from this that in a deposit from which all the aragonite shells have been removed, among 93 specimens of Foraminifera recorded, only one porcellanous form is included, and that presumably in so bad a state of preservation as to forbid specific determination. Judging from the analogy of recent Foraminiferal deposits *from all depths*, the Chalk should have contained originally a considerable proportion of porcellanous species. The chain of evidence was, however, less complete than in the case of larger structures, where casts or replacements have been observed. We therefore tried the action of a solution of carbonic acid on *Miliola* (porcellanous) and *Rotalia* (vitreous) in the fossil state, with the result that the porcellanous species was reduced to a condition in which it was disintegrated by a stream of water, whilst the vitreous species maintained its integrity, neither did it lose its translucency or compact structure. It may be added that the strength of structure of the porcellanous is at least equal to that of the vitreous species.

From experiment and observation we may therefore infer that *Porcellanea* are of inferior stability to *Vitrea* in presence of carbonated water, and consequently that their absence from a formation such as the Chalk does not warrant the assumption of their non-existence at the period of its deposition.

Note.—Subsequently to the reading of the paper our attention was drawn to a communication by Prof. Sollas (Proc. Roy. Soc. Dublin, vol. iv. new series, 1885), in which the author comments on the rarity of Imperforate Foraminifera in the older rocks. The specific gravities were determined in the Sondstadt solution. The values obtained for recent specimens were *Vitrea* 2·626 to 2·674, *Porcellanea* mostly 2·7, but ranging to 2·722. We also have succeeded in obtaining sufficient recent *Spiroloculina* for determination by the specific gravity bottle in a state of fine powder. Two experiments gave respectively 2·70 and 2·71. As we have not yet completed our examination of this group, and the percentage of animal matter has not yet been determined, we express no opinion regarding the mineralogical constitution of the tests, but content ourselves with pointing out that, as in the case of aragonite organisms, opacity in the fossil state accompanies instability towards carbonated water, both probably being related to the *structure* of the shell.

V.—On the Occurrence of Porphyritic Structure in Some Rocks of the Lizard District.[1]

By Howard Fox, of Falmouth, and Alex. Somervail, of Torquay.

BEING the fortunate possessors of Prof. Bonney's valuable papers[2] on the Lizard Serpentines and Schists in a pamphlet form, we examined the coast this spring somewhat minutely from Polurrian Cove on the west to the Blackhead on the east of the Lizard Point. We had tracings of the entire coast in our pockets, taken from the 25 inch Parish Maps, and owing to fine weather, and a favourable state of the coast, we were able to visit some of the less accessible rocks, and to trace some beds which at times are covered with sea-weed and shingle or débris from the falling cliffs. Prof. Bonney's porphyritic diabase had been previously identified by one of us after a long search over the 18 acres of rocks and boulders exposed at Polpeor at low-water spring-tides. We made ourselves familiar with this rock, and were thereby enabled not only to trace it further, but to recognize a porphyritic structure in many dykes and intrusions along the coast, and also in the darker bands of Prof. Bonney's "Granulitic Group."

Commencing at Polurrian, the most westerly point, we will proceed eastward, noting the chief localities where the porphyritic structure may most readily be observed.

Vellan Head.—About 250 yards N.W. of the granitic vein marked on the Ordnance Map, near the base of the cliff and opposite an island, some narrow porphyritic dykes occur in the midst of bands of disintegrated serpentine, steatite, etc., and quartzose rock.

Good Gastol (?).—At the inner end of a little cove about 300 yards S.E. of Oliver's Refreshment Room at Kynance Cove there are some dykes with a few crystals of felspar scattered through their compact dark matrix.

Holestrow.—On the foreshore at the southern end of this land slip and a little N.W. of Pentreath Beach are several masses of banded crystalline rocks *in situ* resembling the "Granulitic Group." In these rocks may be discovered by careful search felspar crystals scattered through the matrix of the darker bands.

Pentreath Beach.—At the extreme north end of this beach a granitic vein runs up the cliff. Adjoining are some trap dykes also cutting the serpentine. About 100 yards south of this point a porphyritic dyke may be seen at low-water running in a N.W. and S.E. direction. This dyke is again found in a chine in the cliff in a line with its strike. At the south end of this beach occurs the junction of the serpentine with hornblende schist. About 100 yards south of this junction we find indications of porphyritic structure in the massive cliffs, here chiefly composed

[1] An Abstract of this paper was read before the British Association, Section C. (Geology), Manchester, September 1887.

[2] Quart. Journ. Geol. Soc. Nov. 1877, pp. 884–928, and Feb. 1883, pp. 1–24.

of micaceous schists. These indications continue for the next 300 yards, viz. to considerably south of Caerthillian, and on the foreshore are seen stones and boulders of typical porphyritic structure.

North Caerthillian.—The most readily accessible place where a typical porphyritic rock may be seen *in situ* is immediately N.E. of the headland which bounds Caerthillian on the north. This spot can be reached with ordinary care from the top of the cliff, which is lower here than on either side. A quartzo-felspathic rock is exposed close under the soil, and a few yards below it are several bands alternating of porphyritic and granulitic rock much faulted. The darker bands are thickly studded with small well-defined crystals of felspar, which on the weathered surface project beyond the matrix. These bands can be traced for 20 yards in a N.W. and S.E. direction, much twisted. They extend in a S.W. direction to high-water mark and down the cleft to the south.

South Caerthillian.—Some rocks apparently *in situ* on the foreshore 70 to 100 yards south of Caerthillian Cove show crystals of felspar in their soft micaceous matrix. The adjoining cliffs show a porphyritic structure in a more compact rock.

Pistil Ogo.—Rounding the Lizard Head, we can descend the cliff at this place, where we find a greenish porphyritic rock running N.W. and S.E., and 200 yards further east we reach the most southern point.

Polpeor.—When the shingle and seaweed have sufficiently left the coast, the porphyritic diabase discovered by Prof. Bonney can be traced running N W. and S.E. for 150 to 200 yards. It is exposed in the micaceous and hornblendic schists in an intricate manner, appearing again and again at and near the base of the cliff and on the foreshore both in Polpeor and the adjoining cove to the N.W. It can be traced in the mass of rock which at half-tide forms the eastern boundary of Polpeor beach, and through this on the foreshore still further east towards Polpeor Island. It appears again in Vellan Drang 200 yards S.W. of Polpeor Cove in the strike of the Pistil Ogo Beds.

Parn Voose (locally Penvose).—This cove directly north of the Balk Quarry is the place at which Prof. Bonney's "Granulitic Group" sets in, and continues with alternations of hornblende schist and serpentine to Kennack Beach. Here also the gabbros appear in mass, and here the porphyritic structure in the dark bands of this crystalline series may be seen to advantage. The foreshore is strewn with boulders recently fallen from the cliff, and the crystals of felspar in some of these are from one to two inches long and almost as broad. The same occurrence of crystals is seen in the cliffs, but not to such advantage as in the boulders.

Polbarrow.—Proceeding still eastward past Lean Water and Gothan Point or Whale Rock, we come to Polbarrow, and can trace porphyritic indications throughout this region.

Kildown.—East of Cadgwith we also find crystals and felspar in the dark bands of the granulitic group.

CAERLEON.—Here Prof. Bonney's porphyritic dyke[1] is seen about 100 yards south of the Poltesco Serpentine Factory.

Passing Caerleon Cove, we climb up the hill by the Coast-guard path, cross the rocky slope above "Little Cove," and scramble down into the next small cove north of a projecting serpentine headland called in the Parish Map Polbream Point. Here we find rocks with large crystals of felspar, both *in situ* and in boulders scattered over the rocky foreshore for the next 300 yards northward.

CAVOUGA.—The Parish Map gives the name of Cavonga to the serpentine rocks running out to sea 100 yards north of Polbream Point, and as the rocks containing large crystals of felspar occur on each side of these serpentine rocks, it may be an appropriate name by which to designate this region.

There are two exposures of these large-crystalled porphyries *in situ* at the foot of the cliffs; the first about 90 yards S.W. of Cavouga Rocks, the second about 200 yards north of them, or say 600 yards N.E. of Poltesco Serpentine Factory. The first of these appears to cut the serpentine, and can be traced up the cliff, the darker bands containing both large and small crystals of felspar at various angles, and the associated lighter bands resembling the quartzo-felspathic bands of the "Granulitic Group." The second exposure north of Cavouga Rocks resembles three dykes cutting through the serpentine; but, as Colonel MacMahon suggests, it may be one dyke which by pressure has been doubled up on itself. Between and on either side of these two exposures the darker bands of this crystalline series of rocks show from time to time distinct crystals of felspar in the massive rocks as well as in those which appear to cut the serpentine as dykes. On the foreshore are many boulders so studded with crystals as to resemble mosaic, the crystals occasionally reaching a length of nearly six inches and a breadth of from two to three inches. One boulder had some of the crystals beautifully tinted with red.

KENNACK.—In proceeding east to Kennack, we trace the crystals in the dark bands of the granulitic group, and on reaching the beach we find the porphyritic structure very marked in some isolated masses of the same group, one of which Prof. Sedgwick described as a "Greenstone porphyry."[2] North of these in a low cliff we trace a similar structure.

GREEN SADDLE.—About 500 yards E.S.E. of the thatched shed at the extreme east of Kennack Beach there is another exposure of rock with large crystals of felspar resembling a dyke cutting the serpentine. The foreshore is here also strewn with boulders of porphyritic rock.

Summary.

The crystals of felspar are found to be most numerous in those rocks which lie in the closest proximity to the gabbro and serpentine;

[1] Quart. Journ. Geol. Soc. Nov. 1877, p. 900.
[2] Trans. Cambridge Phil. Soc. vol. i. p. 18.

they have their long axis at various angles, and are mostly small, except at Parn Voose, Cavouga, and Green Saddle. The felspathic and hornblendic lines often circle round the crystals.

Such is a brief statement of the bare facts of our observations in this particular direction. Without discussing any theory as to the true nature and origin of the whole of the schists, we think that the porphyritic structure, so prevalent in the dark bands of the "Granulitic Group," in many of the micaceous and other rocks, as also in the later intrusions cutting the serpentine, indicates an igneous origin for many rocks hitherto regarded as schists.

VI.—On the Principal Modifications of the Spirals in the Fossil Brachiopoda.

By the Rev. Norman Glass.

DR. DAVIDSON, assisted by the writer, gave a provisional sketch of the classification of the spiral-bearing Brachiopoda in the volume of the Palæontographical Society for 1883.[1] As Dr. Davidson then said, our design was "to assist those palæontologists who might feel inclined to continue the subject." The following notes have been written by me for the same end, and I think that if they are carefully read and compared with the figures in Dr. Davidson's Carboniferous, Devonian, and Silurian Supplements, they will give a tolerably clear idea to the student of a very complex and difficult subject. I have perhaps some claim to write upon this subject from the years of close and continuous investigation which I have devoted to it, and from the fact that I have discovered a large proportion of what is now known concerning the spirals and their connections.

In the "Geologist," 1858 (vol. i. pp. 457–473, folding plate xii.), Dr. Davidson gave figures and descriptions of all that was known up to that date concerning the spirals and their connections. The comparison between these figures and those given in his Carboniferous, Devonian, and Silurian Supplements in 1880 and 1882 is very remarkable as showing how recent have been the great majority of the discoveries in this interesting group. I have thought, therefore, that it might add to the interest of my notes if I gave in each case the date of the discovery and the name of the discoverer, that is, so far as these are known. Of course it will be understood that there are many genera and species which have the same internal characters as to the position of the spirals, their attachments to the hinge-plate,

[1] Anticipating a delay of fifteen months, owing to the retarded appearance of his Monograph in the Palæontographical Volume, the veteran author on the Brachiopoda, Dr. Davidson, published the result of his labours, in association with the Rev. Norman Glass, concerning the calcareous spirals of the Palæozoic Brachiopoda, in the Geological Magazine for 1881 (Decade II. Vol. VIII. pp. 1, 100, 145, and 289), illustrated by Plate V. and fourteen Woodcuts. It will be well for the reader to refer to these articles, as the figures therein given more fully elucidate the present paper, and the whole subject is treated in greater detail by Dr. Davidson; save and except the additional remarks made by Mr. Glass herein, which refer to discoveries of a later date than 1881.—Ed. Geol. Mag.

and their connections with each other, but only the first discovered example will be given of each distinct and peculiar form. The names and dates given in brackets refer in each case simply to the discovery of the calcareous spirals.

The Position of the Spirals in the Shell.

In the *Spiriferidæ* the spirals have their bases facing each other in the centre of the shell, but usually their apices have a more or less upward direction towards the posterior angle of the lateral margins of the shell. This upward direction is very marked in *Spirifera lineata*, var. *imbricata*. The spirals are sometimes directed backwards into the rostral cavity of the ventral valve as well as upwards, for example in *Cyrtina heteroclita*.

In all the other families or groups of the spiral-bearing Brachiopoda the spirals are always so disposed as that a transverse section taken through the greatest circumference of the shell would as nearly as possible pass through the apices of the two spirals and the centre of their respective bases. The spirals which are thus arranged in the shell have, so far as has been ascertained, six different positions in the various genera to which they belong.

Supposing that the dorsal or lesser valve in a specimen of *Athyris* has been removed, the spirals will then appear with their bases facing each other in the centre of the shell, and their apices directed towards the lateral margins of the shell. The five remaining positions of the spirals referred to might all be obtained by rotating the spirals simultaneously each on its own axis—that is, its perpendicular axis, from the posterior to the anterior border of the spiral. (Of course this could not be done in the specimen itself, but the motion might be illustrated by two cones cut out in wood.) Thus, in the case of *Athyris* as described above, if the two spirals were rotated simultaneously outwards each on its own perpendicular axis, that is, the right-hand spiral to the right and the left-hand spiral to the left, the spirals would soon assume the position in the shell and towards each other of the genus *Dayia*, Dav. (Glass, 1880), in which the apices of the spirals face the middle of the lateral portions of the ventral valve. Continuing the rotation *Thecospira* (Zugmayer, 1880) is reached, in which the apices of the spirals face the bottom of the ventral valve. Again continuing the rotation we have successively *Glassia*, Davidson, 1881, in which the apices of the spirals face each other in the centre of the shell, *Zygospira*, Hall (Whitfield, 1862), in which the apices of the spirals are directed obliquely into the cavity of the dorsal valve, and *Atrypa*, in which the apices of the spirals face the bottom of the dorsal valve. And a still further rotation would bring the apices of the spirals to their first position as in *Athyris*.

The Attachments of the Spirals to the Hinge-plate of the Dorsal Valve.

There is not much variety here. In the *Spiriferidæ* the attachments are straight. In the *Nucleospiridæ* and *Athyridæ*, and in

Hindella, belonging to the *Anazygidæ*, the primary lamellæ shortly after attachment to the hinge-plate are bent backwards towards the ventral valve, each lamella forming an acute angle with the commencement of the first convolution of the spiral (this attachment was discovered by Davidson in 1858). In *Nucleospira*, Hall, and *Athyris*, M'Coy (Glass, 1882), this angle is bent or curved under like a beak. In some American species of *Athyris*, M'Coy (Whitfield, 1859), the angle is not acute, but more open and loop-like. In *Atrypidæ* and *Anazygidæ* the primary lamellæ shortly after attachment to the hinge-plate are bent outwards towards the lateral margins of the shell.

THE LOOP, OR THE CONNECTIONS OF THE SPIRALS WITH EACH OTHER.

In the *Spiriferidæ* the principal character is the straight attachment of the spirals to the hinge-plate. In *Spirifera* (Davidson, 1858) the loop is imperfect, consisting of two internal processes, arising from the primary lamellæ, and directed downwards between the spirals, but not uniting. In *Cyrtina*, Dav. (Glass, 1882), these processes unite at an acute angle. In *Spiriferina*, D'Orb. (Davidson, 1851), the loop consists of a straight or curved horizontal band almost on a level with the dorsal surface of the spirals.

In the *Atrypidæ* the principal character is the position of the loop exterior to and above the spirals. The loop is directed downwards, and is simple and rounded (Whitfield says that in some examples of *Atrypa* the loop is acutely angular—this had never been observed, however, by Dr. Davidson or myself). In *Atrypa*, M'Coy (Whitfield, 1866), the loop is small, in *Zygospira*, Hall (Whitfield, 1862), it is much wider, and lower down, and curves upwards towards the hinge.

In the *Anazygidæ* the principal character is the position of the loop rising from the bottom of the spirals. In *Anazyga* (Glass, 1882) the loop is simple and rounded, and exterior to the spirals. In *Hindella*, Dav. (Glass, 1882), the loop is simple and rounded, with a short spinous extremity, and interior to the spirals. In *Dayia*, Dav. (Glass, 1880), the loop is simple and angular, with a short spinous extremity, and it is placed between the primary lamellæ on the dorsal side of the spirals.

In the *Nucleospiridæ* the principal character is the presence of a simple loop, more or less angular, between and near the centre of the spirals, and directed almost horizontally from the dorsal to the ventral side of the spirals—for example, *Nucleospira*, Hall (Whitfield, 1859).

In the *Athyridæ* the principal character is the presence of an internal loop more complex than that of the *Nucleospiridæ*, and extending upwards from the centre of the spirals. The loop of the *Athyridæ* is really an extension in an upward direction of the simple loop of the *Nucleospiridæ*. In *Bifida*, Dav. (Glass, 1882), there is a small bifurcation at the end of the simple loop. In *Whitfieldia*, Dav. (Glass, 1881), the loop is extended further upwards than in *Bifida* by a rather long single process, which occurs between the simple loop

and the bifurcation. In *Meristella*, Hall (Whitfield, 1860), each side of the bifurcation at the end of the simple loop curves round upon itself so as to form a ring. This loop, which thus contains two rings, occurs also in *Merista*. In *Athyris*, M'Coy (Davidson, 1858), there is a roof-like expansion at the end of the simple loop, from the top of which two accessory lamellæ curve upwards and backwards to the inside of the primary lamellæ, and are continued downwards to the centre of the spirals on the dorsal side. In *Kayseria*, Dav. (Glass, 1882), at the end of the simple loop there is a single rounded process, and at the end of this process the loop bifurcates in an upward direction, as in *Athyris*. The accessory lamellæ, however, do not terminate as in *Athyris*, but are continued between the main coils to the end of the spirals.

Thus there are fourteen forms of loop known, most of which have been recently discovered.

Dr. Waagen describes the interior of the genus *Eumetria*. He says, "The primary lamellæ are very strange in their development. They show broad wing-like expansions at their origin, which are sometimes very strongly developed." This "very strange" development had been previously worked out by me, and figured by Davidson in 1881 as existing in *Athyris plano-sulcata*,[1] in which the primary lamellæ near their origin increase in width—the increased width extending downwards nearly to the centre of the spirals on the dorsal side. Dr. Waagen gives a description of the loop of *Eumetria*, and it seems to be similar to the simple loop of the *Nucleospiridæ*, with the exception that the loop commences nearer to the origin of the primary lamellæ, and has a downward direction between the spirals. Supposing this to be correct, the loop of *Eumetria* forms an addition to the number of loops previously worked out.

Davidson gives two figures of the loop of *Uncites*[2] in his Devonian Supplement, 1882. From these figures the loop would seem to be simple and transverse as in *Spiriferina*, with the exception that there is a thickening at the centre of the loop, which on the upper side amounts to a short spinous projection. The attachments to the hinge-plate are straight, as in the *Spiriferidæ*.

With the exception of the spirals in *Thecospira*, and the loops in *Spiriferina*, *Eumetria*, and *Uncites*, all the particulars given above have been carefully verified by my own preparations.

P.S.—I have made no reference in the above article to the eminent Palæontologists by whom the respective genera were determined and described. The discoveries of Mr. Whitfield were described by Prof. Hall, of Albany, U.S. My own were described by Dr. Davidson, whose recognition of any assistance I may have rendered him in his great work was always most generously made. (As see Geol. Mag. 1881, *loc. cit.*)

[1] See Geol. Mag. 1881, Dec. II. Vol. VIII. p. 5, Figs. 2 and 3.
[2] See Geol. Mag. 1881, Dec. II. Vol. VIII. p. 153, Figs. 20 and 21.

VII.—Notes on Carboniferous Selachii.[1]

By Dr. R. H. Traquair, F.R.S., F.G.S.

The *Cladodontidæ.*

THE teeth known as *Cladodus* (type *C. mirabilis*, Ag.) have a flattened, transversely elongated, sub-elliptical or reniform base, the anterior margin being straighter than the posterior and often slightly excavated in the middle. Anteriorly the base is thick, and generally shows a groove separating the truly basal from the coronal portion, while the posterior margin is thin owing to the downward and backward slope of the upper surface. From this upper surface anteriorly spring a number of cones or denticles, of which the median is the longest; it is flanked by lateral denticles, of which an outer one on each side is longer than those intermediate. The larger denticles, at least, are flattened antero-posteriorly and have lateral cutting margins.

There are two exceedingly well-marked species of common occurrence in the British and Irish Carboniferous Limestone, namely, *C. mirabilis*, Ag., and *C. striatus*, Ag. *C. marginatus*, Ag., I also believe to be a good species, as well as *C. Milleri*, Ag. On *C. acutus*, Ag., *conicus*, Ag., *basalis*, Ag., *Hibberti*, Ag., and *parvus*, Ag., I offer no opinion, not having seen the types; but as to the new species added by Mr. J. W. Davis in his large work on the fossil fishes of the Carboniferous Limestone series of Great Britain[2] there is scarcely one which will stand the test of careful comparison with the common species described by Agassiz. *C. Hornei*, Dav., *C. elongatus*, Dav., and *C. curtus*, Dav., are in my opinion simply synonyms of *C. striatus*, Ag.,— *C. mucronatus*, Dav., and *destructor*, Davis, of *C. mirabilis*, Ag. It is rather difficult to give any opinion upon *C. curvus*, Davis.

In the Edinburgh Museum, and in the Collection of the Geological Survey of Scotland, there are a few teeth of what is evidently a new species of *Cladodus*, from the Lower Carboniferous rocks of Eskdale in Dumfriesshire, though I refrain on the present occasion from giving it a name. In these teeth the surface of the cones is perfectly smooth and glossy, and in the absence of striations they approach *C. van Hornei* and *prenuntius* of St. John and Worthen. The thought has struck me, is it possible that this undoubted *Cladodus* may represent the dentition of *Ctenacanthus costellatus*, the unique specimen of which, with the spines *in situ*, occurred in the same beds? It will be recollected that the only tooth visible in the specimen of *Ctenacanthus costellatus* was an imperfect one, but its one visible cusp was smooth. If there is any connection here, the specimen of *Ct. costellatus* must have been a young individual, as these teeth indicate a fish of much larger size.

This brings up once more the question of the correlation of *Cladodus* and *Ctenacanthus*, a question which I must admit is still involved in great obscurity. When I wrote my description of

[1] Read before the Royal Physical Society of Edinburgh, 18th January, 1888.
[2] Trans. Roy. Dub. Soc. 1883.

Ctenacanthus costellatus,[1] I was inclined to believe that *Ctenacanthus* and *Cladodus* represented the spines and teeth of the same genus, and that the genus itself was *Hybodont*.

Mr. Garman, however, in his paper on *Chlamydoselachus* disputes that view, and claims that remarkable recent shark which has only one dorsal fin and no spines at all—a form placed by Dr. Günther in the family Notidanidæ—to be the modern representative of the ancient Cladodonts. It is perfectly true that the small teeth towards the angles of the mouth in *Chlamydoselachus* when seen from the front strongly resemble those of *Cladodus*, yet this resemblance is not very apparent in those which cover the greater part of the jaws, while the bases of the teeth are to my eye strikingly dissimilar. I cannot therefore, without further evidence, accept Mr. Garman's very confident assertion that *Chlamydoselachus* is a Cladodont, leading as it does to the inference that *Cladodus* had no dorsal spines. That *Cladodus* at all events is not quite so close to *Chlamydoselachus* as Mr. Garman believes is, I think, fully shown by a remarkable specimen from the Carboniferous Limestone of East Kilbride, Lanarkshire, which has been lent to me for description by its possessor, Mr. James Neilson, of Glasgow.[2] This specimen was recovered from the quarry in separate pieces by the late Mr. A. Patton, who, I understand, did not feel sure that they all belonged to the same specimen. However, the fragments were pieced together by Mr. Neilson, and after a most careful scrutiny of the whole, I have come to the conclusion that the fragments do belong to the same specimen and are rightly arranged. We have first a head, compressed from above downwards, whose jaws are crowded with truly cladodont teeth of the type of *C. mirabilis*, though apparently belonging to a hitherto undescribed species. This is followed by a mass of crushed and inextricably confused cartilages representing the branchial apparatus, and then come two scapulo-coracoids, each with a pectoral fin attached. The fin of the right side is the better preserved, and shows first a number of elongated radial pieces whose bases, separated from the rest by joints, are attached directly to the shoulder-girdle and evidently represent the propterygium and metapterygium of ordinary Selachii. Behind these is an oblong metapterygium bearing radials preaxially, whose anterior portion seems to have absorbed the bases of one or two adjacent radials, but whose posterior extremity is continued backwards as a long narrow segmented stem consisting of nine rectangular joints, and reminding one at first sight of a vertebral column! This part in both fins is cut off by the edge of the stone, so that its actual length and number of segments are not seen. Some small radials are seen attached to the preaxial side of the first two segments,—none on the others, or on the postaxial side of the stem.

The interest of this specimen is extreme, as it is at least capable of bearing the interpretation that we have here a veritable uniserial

[1] Geol. Mag. Jan. 1884, pp. 3–8.

[2] As I have promised to lay a detailed description of this specimen before the Geological Society of Glasgow, I can only make a few general remarks upon it in the present instance.

archipterygium, intermediate between the truly biserial one of *Xenacanthus* and the pectoral fins of ordinary sharks. If this interpretation is correct, then, along with *Xenacanthus*, this specimen is a witness against the lateral fold theory of the paired fins, at present so popular with anatomists and embryologists. Into that question I shall enter on another occasion, meanwhile so much is clear, that if we have before us the pectoral fin of *Cladodus*, and I do not doubt that we have, the affinity between that genus and *Chlamydoselachus* is not quite so close as Mr. Garman maintains, seeing that in his fish the pectoral fin shows the ordinary arrangement of basal pieces, though the metapterygium has two segments.

What then of the *Ctenacanthus* theory? No spine is seen in connection with the East Kilbride *Cladodus*, but as the body is absent, spines may have been borne by the fish when complete. Again, in the Eskdale *Ctenacanthus* the form and structure of the pectoral fin are not shown, and though I interpreted its one imperfect tooth as "Cladodont," I am willing to leave that an open question. It may be *hybodont*, and the hybodont form with its vertically compressed base must not be confounded with the cladodont type with its base horizontally flattened and irregularly elliptical or reniform. And in one of the instances which have been advanced to prove the connection of *Cladodus* with *Ctenacanthus*, a mistake has certainly been made. So far as I have seen them, the teeth which are found associated with the Coal-Measure *Ctenacanthus hybodoides*, Eg., do not belong to *Cladodus mirabilis*, Ag., as has been asserted, but are allied to *Hybodus* in their narrow, compressed non-expanded bases. Mr. J. W. Barkas long ago expressed his opinion that "most of these so-called *Cladodi* are in reality *Hybodi*" (M. Rev. Dent. Surgery, February, 1874), though he seems to think that the great difference between *Cladodus* and *Hybodus* lies in the former having the outermost denticles larger than the intermediate ones, and consequently admits some of these Coal-measure specimens to the genus *Cladodus*.

Ctenacanthus hybodoides has therefore nothing to do with *Cladodus*, and as regards the other species, I rather think that, if we knew the creatures to which they belonged, they would turn out to represent several types, possibly very different from each other. But of this I have now no doubt, namely, that the Cladodontidæ, whether they had spines or not, or whatever the shape of their spines if they had any, constitute a very different family from the Hybodontidæ—while the latter on the other hand were closely allied to the Cestraciontidæ. For if *Tristychius* be a Hybodont, we have now some clue to the structure of an ancient representative of the family.

Tristychius, Agassiz.

A specimen of *Tristychius*, from Eskdale, allied to, if not identical with Agassiz's *T. arcuatus*, shows the greater part of the body with the head, one pectoral fin and two dorsal fins. Each of the dorsal fins has a spine in front. The pectoral shows two large basal pieces which I interpret as mesopterygium and metapterygium, the propterygium being either small or fused with the mesopterygium as in

Cestracion, while there is no trace of the segmented prolongation of the metapterygium which we saw in the E. Kilbride *Cladodus*.

This interesting specimen is fatal to Mr. T. Stock's idea that the spines in this genus were *paired*,[1] as well as to its location among the Chimæroids as maintained by Prof. Hasse.[2] That it is a Hybodont cannot, in my opinion, be doubted.

Orodontidæ, De Koninck.

If the Mesozoic genus *Acrodus* be a Hybodont,—and its spines are generically indistinguishable from those of *Hybodus*,—it is difficult to draw any line between the Hybodontidæ and Orodontidæ.

One of the genera which De Koninck and Mr. Davis place in this family must, however go, namely, *Lophodus* of Romanowski. Romanowski separated from Agassiz's *Helodus* such forms as *didymus*, *lævissimus*, *mammillaris*, as having one or more prominent elevations on the crown, and a well-developed compressed and vertically striated root, while he considered *H. planus*, which has no such root and no special elevation on its crown, to represent the old genus. Unfortunately both "*Helodus*" *planus* and "*Lophodus*" *didymus* belong to the mouth of the same fish, and that fish is *Psephodus magnus*! Moreover, as I have once remarked, if the old genus *Helodus* was to be divided, surely the characters of the type-species, *H. simplex* of the Coal-measures, ought first to be ascertained and duly considered. Now a fine series of specimens of *Helodus simplex*, Ag., in the collection of Mr. John Ward, F.G.S., Longton, clearly shows that the teeth in this species have the form of "*Lophodus*," that the entire dentition consisted of teeth generally similar in shape, and that the dorsal fins were armed with spines resembling those of *Pleurodus*.

Whatever be the nature of the teeth which Mr. J. W. Davis retains in, and adds to *Helodus*, there can be no doubt that *H. simplex* must remain the type of Agassiz's genus, in which also *Chomatodus cinctus*, Ag., ought to be placed, as already indicated both by McCoy and Davis.

Cochliodontidæ.

The closeness of the alliance between the Cochliodontidæ and Orodontidæ is shown by the fact that the anterior teeth of *Psephodus* and *Cochliodus* are generically indistinguishable from those of *Helodus*.

As seen in *Psephodus*, which is one of the least specialized of the Cochliodontidæ, the posterior teeth lose their deep roots, become flattened, and tend to fuse together into broad inrolled plates. I have a specimen of the broad tooth plate of *Psephodus magnus*, Ag., which by a groove is divided longitudinally into two portions, which pretty closely represent not uncommon forms of *Helodus planus*. The grooves on *Pœcilodus*, *Deltodus*, etc., also to my mind represent the morphological origin of those plates from the fusion of smaller

[1] Ann. and Mag. Nat. Hist. (5), xii. 1883, p. 188.
[2] Natürliches System der Elasmobranchier.

and narrower separate teeth. *Pleurodus* is a well-known form, in which each plate is evidently due to the union, back to front, of a row of helodont teeth whose lateral extremities still tend to project free on each side.

That the Cochliodonts all possessed dorsal spines seems highly probable. Those of *Pleurodus* have been described by Hancock and Atthey.

Petalodontidæ.

If we take *Ctenoptychius apicalis*, Ag., as the type of its genus, I must own that I fail to see any valid reason for separating *Ctenopetalus* from it, and even *Petalodus* is scarcely entitled to distinction. *Harpacodus* differs in having only one fold or plait at the junction of the crown and root, and it is in this genus that Mr. J. W. Davis proposes to include *Ctenoptychius pectinatus* of Agassiz. But *Ctenoptychius pectinatus* is not provided with any "fold" of enamel below the crown comparable to those in *Ct. apicalis*, or to the single one in *Harpacodus*, while its root differs very considerably in shape, being divided below into a number of small rootlets, somewhat after the manner of *Polyrhizodus*. A new genus is therefore necessary for it, for which I propose the name *Callopristodus*.

Oracanthus.

Some time ago Mr. R. Craig, of Langsyde, Beith, lent me a small spine from the shale above the 9-inch coal at Broadstone, Ayrshire (Carboniferous Limestone series), which is apparently undescribed. It is small, flattened and broadly triangular, the anterior margin being 1 inch in length, the posterior $1\frac{3}{8}$, the base $\frac{3}{4}$ inch in breadth. The apex ends in a sharp spike, and just below this on the posterior margin are two others directed backwards. Externally the surface is ornamented with distinct furrows running parallel to the anterior and posterior margins, consequently tending to radiate from the apex towards the base, and giving the surface a feebly ribbed appearance. On these ribs are small tubercles, irregularly placed towards the apex, then becoming arranged in lines which proceed obliquely, or with a slight sigmoid curvature, across the surface from behind downwards and forwards. I have seen other specimens of the same spine from the Carboniferous Limestone "Bone-bed" at Abden, Fifeshire, collected by Messrs. W. Anderson and W. Tait Kinnear, which show that the walls were thin and the spine consequently extremely hollow. In these specimens the external ribbing is also feeble, and the tubercles more thickly placed.

In their general configuration and in the nature of their surface ornament, the resemblance of this spine to *Oracanthus* is obvious, although the posterior area is not so sharply defined, and though neither of the sides is notched or sinuated on the lower margin as is, so far as my observation goes, usually the case in the genus mentioned. It has, perhaps, still thinner walls than in the typical *Oracanthi*, and might on that account be referred to St. John and Worthen's genus *Pnigeacanthus*; but the generic distinction of this from *Oracanthus* is doubtful. No *Oracanthus* has hitherto been described with spikelets

at the apex, but as the apices are more or less worn, a ready explanation of their absence is obtained. I therefore designate this spine *Oracanthus armigerus*, with the remark that if it be not a true *Oracanthus*, it is an excessively closely allied form.

Mr. Davis recognizes that the spines of *Oracanthus* existed in pairs, and are not bilaterally symmetrical, having one side larger than the other; but when he refers them to the "posterior termination" of the body, hints at removing the genus to the "Placodermic Ganoids," and figures a whole series of really undeterminable fragments as bones of the head of this supposed Placoderm, we can hardly follow him. I have carefully gone over all the specimens in the British Museum which he has figured as "upper jaw," "central bone of cranium," etc., and can find no evidence for such determinations. I have also examined microscopic sections of *Oracanthus*, and find that they consist of Selachian dentine. And we may also appeal to the obvious resemblance, which the spines of *Oracanthus* bear to the thin-walled triangular appendages often found associated with *Gyracanthus*. which, though not "carpal bones," as Messrs. Hancock and Atthey imagined, are unquestionably Selachian in their nature.

The writer of a review of Mr. Davis's work, which appeared in the Geological Magazine for November, 1883, does not believe that the *Oracanthi* formed the posterior extremity of the body of a Placodermic Ganoid, but that "it seems probable that they may have occupied a lateral position on the head of these old Elasmobranch fishes." And if I am right in my determination of *Oracanthus armigerus*, sufficient corroboration of this view has now turned up.

In the Museum of Science and Art, Edinburgh, there is a specimen from the Eskdale beds, showing the head of a small Selachian, crushed vertically, along with part of the body, the latter being, however, bady preserved. In the head are broken remains of several large flattened-convex tooth-plates, extremely Cochliodont in aspect, but too imperfect for identification with any known genus or species. But the great point of interest is that each postero-lateral angle of the head projects in a pointed process like the corner of a *Cephalaspis* buckler, and that process is—the spine which I have described as *Oracanthus armigerus*.

I think there can be no further doubt that the position of the *Oracanthus* spines is on the head of a Selachian, and not on the tail of a Placodermic Ganoid.

Addendum to *Cladodontidæ*.

I have long been of opinion that the teeth from Borough Lee, which I described as *Cladodus bicuspidatus*, and which never show more than two cones, a large one and one small lateral one, which is absent in some specimens, ought to be included in a new genus distinct from *Cladodus*. I therefore propose for this form the name *Dicentrodus*, and venture to express an opinion that it will turn out to be more allied to *Diplodus* than to *Cladodus*.

NOTICES OF MEMOIRS.

W. P. Jervis on Earthquakes.

IL CAV. W. P. JERVIS, F.G.S., Keeper of the Royal Industrial Museum of Italy, has published his Lecture to the Philotechnic Society, Turin, on the nature and causes of Earthquakes, with especial reference to that of February last at and near Mentone. This is a careful study of the earthquake of 1887 in North-western Italy and the neighbouring parts of France and Switzerland, establishing certain facts and advancing some possibly new hypotheses. An earthquake-area being regarded as that in which the shocks have sufficient force to be sensible to man, this earthquake had no connection with any volcanic action, and the movements were not propagated to the volcanic region of Central and Southern Italy. An outward external area, including the parts where the seismic disturbance was manifested by very delicate instruments and magnetized bars, would, however, bring us nearer to the region of extinct volcanoes in Central Italy.

After a close examination of the disturbance of springs and fountains, caused by the sliding or derangement of strata close to the surface, the result arrived at was that Mont Mercantour in the Maritime Alps, west of the Col di Tenda, was the centre of seismic action. That mountain and others associated with it seem to have been the foci of an elliptical, but nearly circular, area of shocks, with its greater axis of about 485 kilometres. The length of the axes of the outer area of shocks perceptible only by seismic or other instruments cannot be determined, the movements depending on the nature of the rocks; probably they were twice the length of the other axes. The summit of the Maritime Alps, from a short distance N.W. of the Mercantour to the junction of the Alps and Apennines above Savona, seems to have divided the earthquake-area. That part towards the Mediterranean and the bed of the sea itself were subject as well to vorticose as to undulatory and subsultory shocks. The lateral boundaries were defined by slight fissures (from one to two or three millimetres wide) in the rocks or soil, in a direction perpendicular to the Maritime Alps, from near the Mercantour to the vicinity of Mentone, and from the mountains to near Savona. The vorticose action was most curious, especially near Mentone, where crosses and upper stones or statuettes of marble were turned round 30° or 45° in the Protestant cemetery. Elsewhere only undulatory and subsultory shocks were apparent. A table of places affected, duration of shocks, and geological nature of the ground is given. Some of the physiological effects before and during the earthquake are noticed, also the hearing of strange sounds in the stillness of the night, as if at a great depth underground.

The slow changes of level along the coast from Marseilles to

Genoa,—the sinking of Roman buildings below the sea-level at the coast-line near the former mouth of the Rhone,—and the fact of stone-boring Molluscs being found many metres above the sea-level in other parts—led Issel to say that this coast-line is subject to slow upheavals and depressions; and these Mr. Jervis believes to be due to the district being the area of repeated earthquakes similar to that of last spring. But as the earthquakes seem to be due to the descent or sinking of mountain-masses towards the centre of the globe, it would seem that they could not be repeated without the gradual lowering of the mountains. Mr. Jervis, however, proposes the hypothesis that there is an extra-mundane cause of upheaval of certain mountain-groups. Referring to Flammarion as being probably correct on the whole, though very poetic and too much of a scenic artist to follow details patiently, Mr. Jervis proceeds with the idea that the sun and moon, in certain positions, may be able to attract a given mountain-mass very gradually, and to an exceedingly small extent,—such process being repeated again and again, each time causing a still further elevation of insensible height. In time, unstable equilibrium having been produced (especially at given moments following the transient recurrences of celestial attraction), terrestrial gravitation interferes, and the upheaved masses settle down, in some instances with rupture of the strata. Thus there are two phases of the disturbance;—first, a gentle and imperceptible upheaval, so gradual as to be unappreciable by our senses, and never yet established, except on a coast-line where the sea-level gives a fixed point of comparison. This might, however, be as fully proved inland, were the heights of fixed objects on mountains (such as the summit of a building, a signal stone, etc.) determined with mathematical precision, instead of the ever-varying mountain-top (as Mont Blanc) being taken, which may be worn down one to twenty feet in a century by frost and rain, and possibly be again upheaved from time to time so as to restore the geographical relief.

The earthquake, as it is called, would then be the phenomena caused by the influence of terrestrial gravitation,—the fall by which stable equilibrium is secured. In the author's opinion the elevatory process by far exceeds that of depression, allowing full play for the ever-active erosion, by which the Alps, for instance, may have been worn down even hundreds of feet in historic times. Are not earthquakes, then, absolutely necessary for restoring in some parts of the globe the equilibrium of certain forces and agents, as electricity? Do they not help to maintain the balance between the heights of mountains and the depths of seas?

The defective method of buildings, especially with vaults, allow of much of the disasters in earthquake-areas, and the author points out some practical technical precautions and the building-materials most fit for use in these places.

REVIEWS.

I.—The Ancestry of our Animals.

Les Ancêtres de nos Animaux dans les Temps Géologiques. By Albert Gaudry. 12mo. (Paris, 1888.)

In this fascinating little volume of 296 pages, illustrated by a frontispiece and 48 woodcuts, of which several occupy an entire page, and are printed as plates, we are glad to welcome another of Prof. Gaudry's valuable and interesting contributions to the history of Fossil Mammalia.

The first chapter is a brief *résumé* of some of the more important steps in the progress of Palæontology, with a list of names of many famous workers in various branches. In the second we have an interesting discussion on the importance of the degree of evolution of the contained fossil Vertebrates in regard to the determination of the age of strata in different parts of the globe; in which is given a valuable table of the date of appearance of some of the more important groups of Vertebrates. Great weight is here attached by the author to the degree of specialization of the various genera of Selenodont Artiodactylia, as indicative of the relative age of the beds in which they occur: and illustrations of the doctrine of migration and colonization are given from the Mesozoic Mollusca. With the third chapter we enter on the proper subject of the volume—or the evolution of the Tertiary Mammalia; and here we find a large number of excellent illustrations of the chief types of dental and pedal structure, reproduced from the author's larger work on the same subject. This subject in the two succeeding chapters is further specially illustrated by the history of the fossil Mammals of Pikermi in Attica, and of Mont Leberon in Vaucluse, which have been rendered classic by the author's earlier monographs; and some very interesting suggestions are made as to the influence which the fossil bones of the former area may have exerted on the mythologies and metamorphoses of the Greek and Roman classic writers.

The last two chapters are devoted more especially to the Palæontology of the Paris Museum; the seventh containing a review of the works of the author's predecessors in the chair of Palæontology. Excellent figures are given in the eighth chapter of some of the more important skeletons of Mammals which adorn the Mammalian Gallery, among which we may especially notice *Mastodon angustidens*, *Glyptodon typus*, *Palæotherium magnum*, and *Scelidotherium leptocephalum*.

We may conclude our brief notice of this volume, which we can heartily commend to all our readers—whether they be palæontologists or not—by some extracts from the end of the sixth chapter which are well worth the attention of those who are flooding our literature with the names of legions of so-called new species and genera.

M. Gaudry observes, "We must acknowledge that although the old

system of making a special name for the slightest variation is convenient, yet in distinguishing varieties from species palæontologists are exposed to many errors. In the living world, when the descendants from a single type present differences, which do not prevent the production of fertile offspring with the parent form, they are considered merely as varieties of the same species; but when these differences are such as to prevent the production of fertile offspring, they are regarded as indicating a different species. In palæontology not only are we unable to avail ourselves of this criterion, but it is difficult to guide ourselves by the analogies offered by existing animals, since there is an extreme inequality in the external characters separating varieties and species; as, for example, the varieties of the Dog differ more from one another than does the Ass from the Horse.

"This shows that we can only approximate among fossil forms to the degree of difference indicating a variety or a species. But, in order to come as near as possible to the truth, we should adopt the following plan:—viz. that when the differences separating fossil animals are of no importance from an evolutionary point of view, we may be permitted to regard such animals as mere varieties of a single species; that is to say, that they were all probably capable of producing fertile offspring among themselves."

Numerous examples are then cited of differences which may be regarded respectively as varietal and specific; the different proportions of the limb-bones of the Pikermi Hipparions being given as an instance of the former, while the three digits of the European *H. gracile* as contrasted with the single one of the Indian *H. sivalensis* are instanced as good specific characters.

In conclusion it is observed, "That whatever may be the difficulty in marking the distinction between fossil species and varieties, I consider this distinction as worthy the attention of naturalists. The history of past forms reveals, indeed, a succession of undefinable differences (*nuancés indefiniés*), which the Divine Wisdom can coördinate, but to desire to mark each of which by a special name is to only prepare lists without end, in which human weakness must lose itself!"

We cordially agree with these concluding remarks, and have no doubt that the author would extend them to embrace genera and the larger groups. The time has, indeed, come when we ought to accentuate the resemblances rather than the differences which we find among allied fossil forms; and to recognize that both in the case of specific and generic names it is advisable to use them in a much wider and less defined sense than we are accustomed to do when our study is restricted to the comparatively small fauna of the present day.

R. L.

II.—DEN NORD-NORSKE FJELDBYGNING. AF KARL PETTERSEN. Separataftryk af Tromsoe Museums Årshefter X. Tromsoe, 1887. 8vo. pp. 174, taf. i—iii.

THE author has been engaged since 1865 in working out the geological structure of the mountain district of North Norway,

and he now proposes to give in a connected form the results of his researches. This first part treats more particularly of the oldest series of the Archæan rocks, which is developed throughout the island bordering the coast, from Lofoten to the North Cape, and on the deeply indented coast-line of the mainland, and again makes its appearance in the interior of the country near the border-line between Norway and Finnish and Swedish Lapland. The rocks of the littoral or western series are named by the author *gneiss-granite*, whilst those of the Eastern are termed the *inland granite*. Between these series, which have a generally south-west to north-east direction, there is a belt of newer crystalline schists about 100 kilomètres (62 miles) in width, which the author believes to be deposited in a basin-shaped depression of the older rocks.

The gneiss-granite series consists of beds of gneiss intermingled with granite, but the granite presents no evidence of having been subsequently intruded into the gniess; it is of the same character as the gneiss, and there is a gradual transition from the one into the other. There are also frequent beds of pure quartz interdeposited in the gneiss-granite series. The author believes that all these rocks are of sedimentary origin, and that the materials of the gneiss have been derived from older granitoid rocks, which could not have been situated in the Scandinavian Peninsula or to the east of it, but probably existed in the area now occupied by the North Atlantic Ocean. From this supposed ancient continent the author believes that the Laurentian gneiss of North America was also derived, as well as those newer crystalline schists which fill up the basin formed by the gneiss-granite series in the Scandinavian Peninsula. These schists reach a thickness of 1000 mètres, they are quite unfossiliferous, but they are believed to belong to the Cambrian or lowest Silurian epoch.

The author gives an orographical review of the region and detailed descriptions of the geological structure of the different islands, as well as vertical sections in the accompanying plates. G. J. H.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—December 21, 1887.—Prof. J. W. Judd, F.R.S., President, in the Chair.

The President announced that the Fourth Meeting of the International Geological Congress will be held in London in September next on the 17th and following days. An Organizing Committee has nominated the following Officers:—*Honorary President*, Prof. T. H. Huxley, D.C.L., LL.D., F.R.S. *President*, Prof. J. Prestwich, M.A., F.R.S. *Vice-Presidents*, the President of the Geological Society, the Director-General of the Geological Survey, and Prof. T. McKenny Hughes, M.A. *Treasurer*, F. W. Rudler. *General Secretaries*, J. W. Hulke, F R.S., and W. Topley. Steps are being taken to enlist the cooperation of all persons interested in Geology

and the allied branches of science. Particulars will be immediately announced by the Committee.

Fellows of the Society are invited to join the Congress and to assist in making the Meeting a success.

The following communications were read :—

1. "On the Correlation of some of the Eocene Strata in the Tertiary Basins of England, Belgium, and the North of France." By Prof. Joseph Prestwich, M.A., F.R.S., F.G.S.

Although the relations of the several series have been for the most part established, there are still differences of opinion as to the exact relation of the Sable de Bracheux and of the Soissonnais to the English series; of the Oldhaven Beds to the Woolwich series; and of the London Clay and Lower and Upper Bagshots to equivalent strata in the Paris basin. The author referred to the usual classification of the Eocene Series, and proceeded to deal with each group in ascending order.

The *Calcaire de Mons* is not represented in England, but may be in France by the Strontianiferous marls of Meudon. It contains a rich molluscan fauna, including 300 species of Gasteropods, many of which are peculiar, but all the genera are Tertiary forms. The *Heersian* are beds of local occurrence, and the author sees no good reason for separating them from the *Lower Landenian* or *Thanet Sands*. He gave reasons for excluding the *Sands of Bracheux* from this group. Out of 28 Pegwell-bay species, 10 are common to the Lower Landenian, and 5 to the Bracheux Sands, which present a marked analogy with the Woolwich Series. These Sands of Bracheux are replaced in the neighbourhood of Paris by red and mottled clays. Out of 45 species at Beauvais only 6 are common to the Thanet Sands and 10 to the Woolwich Series. Out of 75 species in the *Woolwich and Reading Beds* 19 occur in the Bracheux Beds, if we add to these latter the Sands of Chalons-sur-Vesles.

Respecting the *Basement Bed* of the London Clay (*Oldhaven Beds* in part), the author would exclude the Sundridge and Charlton fossils, which should be placed on a level with the Upper Marine Beds of Woolwich. He allowed that the former were deposited on an eroded surface, but this involves no real unconformity, whilst the palæontological evidence is in favour of this view, since out of 57 species in the Sundridge and associated beds, only 16 are common to the London Clay. He therefore objected to the quadruple division. Either the Oldhaven should go with the Woolwich or with the Basement Bed. He admitted that the term "Basement Bed" is objectionable, and preferred Mr. Whitaker's term for the series, as he would limit it.

The *Lower Bagshot Sands*.—The author would call "London Sands," whose Belgian equivalent is the Upper Ypresian, and the French the Sands of Cuise-la-Motte, forming the uppermost series of the Lower Eocene. A group of fossils has been discovered in the Upper Ypresian sands of Belgium, which leaves no doubt of their being of Lower Eocene age, and consequently the Lower Bagshots must be placed upon the same horizon. There is no separating line of erosion between the London Clay and the Lower Bagshots, the

upper part of the former is sandy, and the lower part of the latter frequently argillaceous. Similarly no definite line can be drawn between the Upper and Lower Ypresian; but in both countries this series is separated from overlying beds by a well-marked line of erosion. So also in France the base of the *Calcaire Grossier* (Bracklesham Beds) is a pebbly greensand resting on an eroded surface of the Sands of the Cuise-de-la-Motte. In Belgium, in Whitecliff Bay, and in the Bagshot district the Upper Eocene rests upon an eroded surface of the Lower Eocene. Subjoined is the author's proposed classification of the Eocene:—

	England.	Belgium.	France (Paris Basin).
Upper.	*a.* Barton Beds.	*a.* Wemmelian.	*a.* Sables Moyens or Grès de Beauchamp.
	b. Bracklesham Beds. = Upper and *b**. Middle Bagshots.	Lakenian and Bruxellian.	*b.* Upper Calcaire Grossier *b**. Glauconie Grossière.
Lower.	Wanting.	Paniselian	Sands of Cuise-la-Motte.
	London Sands = Lower Bagshot.	Upper Ypresian.	
	London Clay.	Lower Ypresian.	Wanting.
	Basement or Oldhaven Beds. Woolwich and Reading Beds.	? Upper Landenian.	Sables Inférieurs of the Soissonnais, including the Marls and Sands of Rilly, the 'Lignites' and Sands of Bracheux.
	Thanet Sands	Lower Landenian and Heersian.	Sands of St. Omer, Douai, and La Fère.
	Wanting.	Calcaire de Mons.	Strontianiferous Marl of Meudon?

2. "On the Cambrian and Associated Rocks in North-west Caernarvonshire." By Prof. J. F. Blake, M.A., F.G.S.

After referring to the published views of Professor Sedgwick, Sir A. C. Ramsay, and the Geological Survey, Professors Hughes and Bonney and Dr. Hicks concerning the area in question and especially as to the presence or absence of Precambrian rocks, the author gave an account of his own explorations and their results, the principal of which were the following.

In the Bangor and Caernarvon area three distinct conglomerates had been confounded. The only one that showed distinct unconformity on the underlying rock was of Arenig (Ordovician) age. The rocks of the southern and central portion of the area were essentially of igneous origin and might be distinguished into two groups, the southern probably intrusive, the northern certainly eruptive. There is no evidence to show what interval of time elapsed between the production of these two groups, nor which of them is the earlier, although the author regards it as more probable that the southern mass is of the earlier date and overlain by the northern portions. The Bangor beds are derived from the denudation of the

volcanic series, and of rocks which may have been associated with it, and they contain a series of conformable conglomerates of which the great conglomerates near Bangor are members. They are the continuation of the Cambrian rocks seen to the east, and have not undergone any serious alteration. The porphyries of Llyn Padarn and Moel Tryfaen are contemporaneous lava-flows in the midst of the Cambrian series, the overlying conglomerates being derived from them and from the sedimentary Cambrian rocks to the west; and hence there is no certain proof of there being any Precambrian rocks in the whole district, though it is probable that the rock near Caernarvon belongs to an epoch distinct from and anterior to the Cambrian.

II.—January 11, 1888.—Prof. J. W. Judd, F.R.S., President, in the chair.—The following communications were read:—

1. "On the Law that governs the Action of Flowing Streams." By R. D. Oldham, Esq., F.G.S.

The author, after describing how his attention was drawn to the subject, proceeded to an investigation of the law that governs the action of a flowing stream. Having accepted as a fundamental principle that the velocity of a stream will always tend to become such as is just sufficient to transport the solid burden cast on to the stream, and pointed out that the principle is almost axiomatic in its nature, he finds that, where untrammelled by exterior conditions, a stream will be alternately confined to a single, well-defined, deep channel, and spread out into a number of ill-defined, shallow channels, the former being defined as a "reach," the latter as a "fan," that the gradient in the "reach" is less than in the "fan," and that both "reach" and "fan" will continually be encroaching at their upper ends, and being encroached upon at their lower ends.

After detailing some general considerations which show that what should occur according to hypothesis does actually occur in nature, he indicated that the accurate and detailed levels taken in connexion with the Ganges Canal do actually show this alternation of "reach" and "fan," that the gradients are higher in the latter, as they should be, and that the records of the Canal show the retrogression of "fan" and "reach" demanded by the hypothesis.

Accepting this agreement of fact with hypothesis as proof of the correctness of the latter, it follows that the fundamental principle on which it is founded is correct, and that, in the absence of interfering causes of greater potency, it is the coarseness or fineness of the débris cast upon a stream that will determine its gradient and velocity, and not, as stated in text-books, the velocity of a stream that will determine its gradient and the coarseness of the débris transported by it:—a conclusion that might be arrived at independently, from the fact that it is in the upper reaches of a stream, where coarse débris prevails, that high velocities of current prevail, while in the lower reaches, where the débris is finer in grain, the velocity of current is also diminished.

2. "Supplementary Notes on the Stratigraphy of the Bagshot

Beds of the London Basin." By the Rev. A. Irving, B.Sc., B.A., F.G.S.

This paper contained the results of field-work during the year 1887. Additional notes on the stratigraphy of the Bracknell and Ascot Hills were given, justifying the reading of the country as shown in figs. 1 and 2 of the author's last paper (Q.J.G.S. August, 1887), the examination of this line of country having been extended as far as Englefield Green. Sections of the beds of the Middle Group as they crop out at Cæsar's Camp, Swinley Park, Ascot, and Sunningdale, were described and correlated with the 76 feet of beds which constitute that group in the Well-sections at Wellington College.

The stratigraphy of the hills known as Finchampstead Ridges has been worked out from numerous sections on their flanks; and the strata of the Bearwood Hills were correlated directly with them.

All along the northern margin a general attenuation of (*a*) the Lower (fluviatile) Sands, and of (*b*) the Middle (green earthy) Sands was shown to occur, and in some places on the northern margin they are found to have entirely thinned away, admitting of distinct overlap at more than one horizon.

The second part of the paper dealt with the Highclere district, where the author believes he has established the full succession of the three stages of the Bagshot formation, a section being given across the valley south of Highclere Station, showing the succession of the whole Eocene series (with the *Ostrea bellovacina*-bed for its base) as it is developed there.

Some important conclusions were drawn as to the Tertiary physiography of the South of England; and the revised tabulation of the Tertiaries put forward by Prof. Prestwich at the Society's last meeting was referred to as supporting some of the main points for which the author has contended.

3. "The Red-Rock Series of the Devon Coast Section." By the Rev. A. Irving, B.Sc., B.A., F.G.S.

From a recent examination of this section, and from the facts furnished by Mr. Ussher's paper (Q.J.G.S. vol. xxxii. pp. 367 *et seq.*), the author has arrived at the conclusion that the series of red rocks between the Lias to the east of Seaton and the Carboniferous of Devon, formerly described under the title of "New Red Sandstone," cover the period of geologic time which that term signified, and that the lower members of the series belong, not to the Trias, but to the Permian or Post-Carboniferous.

He considered that at the base of the Budleigh-Salterton pebble-bed there is a physical break of as much significance as that between the Trias and the Permian of the Midlands. From this point eastwards the Triassic system is represented by a series of rocks quite comparable with the Bunter and Keuper of the Midlands, the Bunter being here represented by the Middle Division (about 200 feet thick) and the Upper Division of Prof. Hull.

These pass under the basement sandstone-series of the Keuper below High Peak and Peak Hills, are brought up again by faulting at Sidmouth, and dip beneath the Keuper again east of the Sid,

from which point eastwards the whole Keuper Division is exposed, with quite a normal facies, as seen in the Midlands, in Central Germany (Thüringen, Jena), and in the Neckar Valley.

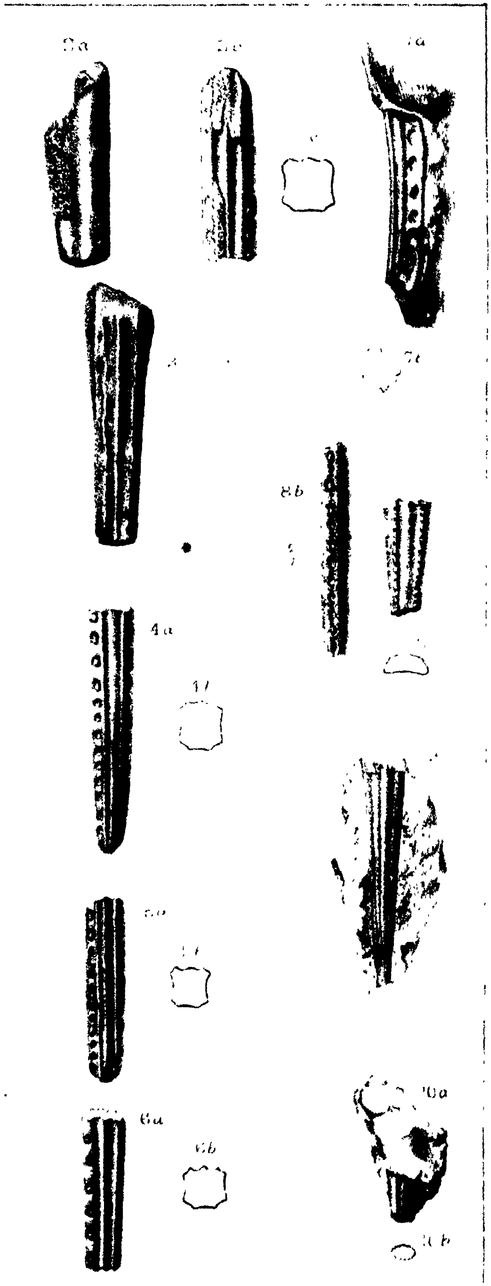
In the marls which underlie the Budleigh-Salterton Pebble-bed, he recognized the equivalents of the Permian Marls of Warwickshire and Nottinghamshire, and of the Zechstein Marls of Germany. These pass, by a gradual transition, through Sandstones, becoming more and more brecciated, into the great brecciated series of Dawlish and Teignmouth, which were regarded as the equivalents of the great Permian breccias of the west of England, of Ireland, and of the Lower Rothliegendes of Germany.

All the rocks below the Budleigh-Salterton Pebble-bed were regarded as the assorted materials furnished by the detritus of the Palæozoic mountain-region of Devon, Cornwall, and Brittany, and as representing the waste and degradation of that region, deposited on the mountain-flanks and in land-locked bays during Post-Carboniferous times, the marls being compared with the Nyirok of the Austrian geologists.

CORRESPONDENCE.

ERRATIC BOULDERS.

Sir,—Your notice of Prof. Hull's paper on "Boulder Stones," read before the British Association last year, recalls my attention to an interesting example of a boulder I came across during a geological excursion in the Grantham district (Sheet 73) some four or five years ago, which I believe exceeds the dimensions of the largest given by Prof. Hull. I had stayed the night at the village of Marston, about five or six miles west of Ancaster, and was making my way in the early morning towards the quarries of our noted Lincolnshire freestone, situate at the latter village, when I noticed a rough accommodation road metalled with Lincolnshire Oolite. This struck me as rather strange, there being several quarries in the Marlstone much nearer at hand. I followed it up, and ultimately found the quarry from which the stone was obtained, a quarry in Lilncolnshire Oolite! at least five miles further west than one would expect to find such a thing. The quarry, on examination, proved to be excavated in a huge boulder stranded on a hill of Middle Lias clay capped by Marlstone. The boulder was almost covered by a very tough chocolate-coloured Boulder-clay, containing Lias fossils, and grassed over. A roadway was cut into it for a distance of twelve or fifteen yards (writing from memory). The definite outline of boulder was obscured in all directions except the entrance to the quarry, where the workmen had cut down to the Lias below, the lines of bedding dipped about 20 per cent. N.W. This stone had probably travelled from the neighbourhood of Ancaster, five miles east, where the line of cliff (escarpment of the Oolites) is cut back and forms a sort of gorge; this is the nearest point it could possibly have come from.



E.C. Knight lith. West, Newman & Co. imp.

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ORIGINAL ARTICLES.

I.—On Some Scandinavian Phyllocarida.

By Prof. T. Rupert Jones, F.R.S., and Dr. Henry Woodward, F.R.S.

(PLATE V.)

SOME Phyllocarida from the Silurian strata of Scandinavia (Sweden and the Island of Gothland) are represented by specimens in the State Museum at Stockholm. Drawings, casts, or the specimens themselves have been shown to us by our friend Professor Gustav Lindström, F.C.G.S., and we have arrived at the following conclusions as to their relationships.—See the "Fifth Report on the Fossil Phyllopoda of the Palæozoic Rocks," read at the Manchester Meeting of the British Association for the Advancement of Science, September 3, 1887 (printed and issued at the same date), pp. 1-3.

1. Ceratiocaris.

Monograph of the British Palæozoic Phyllocarida, Pal. Soc., by T. R. J. & H. W., 1888, pp. 9–13.

1. Ceratiocaris Angelini, T. R. J. & H. W. Plate V. Fig. 1.

Fifth Report, etc., 1887, p. 1.

This unique specimen is a long, stout, trifid caudal appendage, consisting of the style or telson (145 mm. long, and 17 mm. broad at the top) and two stylets (each 75 mm. long) lying close together. One of the latter and the style have been broken across by a crush, and the style is not quite perfect at the tip (possibly 15 mm. longer originally). The lower (ventral) surface only is shown. The articulation of the stylets with and beneath the shoulders of the style—that is, under the backward extension or overhanging hinder edge of its head or proximal end—is very distinct. The upper edge of this part of the style (the surface articulating with the ultimate segment) has an undulated profile, with two small, projecting, unsymmetrical, curved, horn-like processes.

The style on this its lower aspect has a deep groove along the middle of its upper moiety (obscured at the top), becoming narrow lower down. A slight groove on each side is also present. No delicate ridging is seen, nor any pits for bases of prickles. The stylets are smooth, and apparently subtriangular in section, each bearing one strong ridge on the upper part of the under face (as exposed).

In these features this form differs from *C. Bohemica*,[1] Barrande, the telson of which is not deeply furrowed on its ventral (under) face; and the latter species has longer stylets, oval in section, and neatly ridged throughout.

The Scandinavian specimen occurs, as an impression, in hard black shale ('Brachiopod-Skiffer') from the Lower Silurian (Upper Caradoc) of Westergötland (Westrogothia), a province in the western part of the mainland of Sweden. It has been badly figured in Angelin's unpublished 'Tab. LIII.' figs. 18 and 19. Fig. 1 is taken from a plaster cast.

2. Ceratiocaris Bohemica, Barrande. Plate V. Figs. 2—6, 10.

1853. *Ceratiocaris* (*Leptocheles*) *Bohemicus*, Barr. "Neues Jahrb. für Min." etc. 1853, Heft. iii. p. 342.
1868. *Ceratiocaris Bohemicus*, Barr., in Bigsby's "Thesaur. Silur." p. 199.
1872. *C. Bohemicus*, Barr. "Syst. Sil. Bohême," vol. i. Suppl. p. 447, pl. 19, figs. 1-13.
1885. *C. Bohemica*, T. R. J. & H. W. "Third Report on the Palæozoic Phyllopoda," p. 31 (p. 356, Brit. Assoc. Report for 1885); and Fifth Report, etc., 1887, p. 2.

In this species the ultimate segment, 50 mm. long, has a linear longitudinal ornament of interrupted raised lines. The telson more than 112 mm. (4½ inches) in length, is ridged and furrowed, and has pits (marking the bases of former spines and prickles) along the two outer slopes of its dorsal surface. The lower face has a broad median furrow and two lateral hollow slopes. The head of the telson has a linear ornament like that of the ultimate segment. The stylets are ridged and furrowed, and are somewhat oval in section.

Four specimens (Figs. 2, 4, 5, 6), from the cream-coloured limestone (Wenlock Shale) of Eksta, Gothland, are portions of the shafts of straight, strong styles (telsons), similar to that of *C. Bohemica*, and chiefly from the middle and lower parts of the styles. In section these Scandinavian specimens are more equally quadrate than in Barrande's figs. 7 and 9, pl. 19, "Syst. Sil. Bohême," vol. i. Suppl., and the fluting on the lower face is somewhat different. One piece, Fig. 4, is the same as "fig. 5" of Angelin's unpublished plate "Table B."

Another piece of telson (Fig. 3) of the same kind as the above, shown by a drawing from Stockholm, is from the Sandstone of Bursvik, South Gothland (Wenlock Shale).

A small fragment (Fig. 10) from Lau, Gothland, in cream-coloured fossiliferous limestone (Wenlock), is probably part of a stylet of *C. Bohemica*, comparable with, but much smaller than, figs. 4, 5, of Barrande's pl. 19. It tapers rather rapidly, bears several thin ridges on both faces, and is oval in section.

2*. Ceratiocaris valida (?), J. & W. Plate V. Fig. 7.
Monogr. Foss. Phyll. 1888, p. 20.

This is a fragment of strong thick telson in cream-coloured limestones, differing from *C. Bohemica*: (1) in being curved (the

[1] Syst. Sil. Bohême, vol. i. Supplement, p. 447, pl. 19, figs. 1-13.

convexity is dorsal, that is, on the upper surface), (2) in having the two pitted slopes lower down on the sides, and (3) in the section being less quadrate than in *C. Bohemica* proper. In many respects it approaches *C. valida*, J. & W. In whitish limestone with Strophomena, Trilobites, Tentaculites, Encrinites, etc. (Wenlock Limestone), from Rohne, Gothland.

3. Ceratiocaris, sp. Pl. V. Fig. 9.

1887. *Ceratiocaris*, sp. nov.? T. R. J. & H. W. Fifth Report, etc. p. 2.

A fragment of a style or of a stylet. It is somewhat like the last (Fig. 10), but the ridges are fewer, broader, and rounded. This is a drawing sent from Stockholm. The specimen ("Mus. Geol. Survey Sweden") was from Fröjel, Gothland (Wenlock Shale). The "fig. 6" in "Angelin's" unpublished "Tab. B" is somewhat like this, but shows six, instead of four rounded ridges.

4. Ceratiocaris concinna, T. R. J. & H. W. Plate V. Fig. 8.

1887. *Ceratiocaris concinna*, sp. nov. Fifth Report, etc. p. 2.

A small portion of a straight, rapidly tapering style, convex on the upper, and concave along the lower face. The section is half-moon-shaped in the upper, and more oblong in the lower part. Two rows of small pits on narrow ridges along the back, one on each side of the raised middle. The test is of a dull, light chestnut tint; it is hollow and filled with limestone. From Fröjel, Gothland. This tapering telson (7 mm. broad at the top, and 4½ mm. at the end of the fragment 15 mm. long), differs from any we know of, though it approaches that assigned to *C. patula*, J. & W. Being very neat in aspect, it has been called *concinna*.

5. Ceratiocaris Scharyi, Barrande. Plate VI.[1] Fig. 1.

1872. *C. Scharyi*, Barr. "Syst. Sil. Bohême," vol. i. Suppl. p. 454, pl. 32, figs. 24-29.

1876. *C. Scharyi*, F. Rœm. "Leth. geogn." Th. I. "Leth. pal." Expl. pl. 19, fig. 6.

1885. *C. Scharyi*, T. R. J. & H. W. Third Report, etc. p. 31 (Brit. Assoc. Report for 1885, p. 356): and 1887, Fifth Report, etc., p. 3.

Of this species seven segments (75 mm., ultimate segment 23 mm. long) were described by Barrande. Height of the highest (sixth from the end), 20 mm.; height at the end of the ultimate segment, 10 mm. Proximal portion of the trifid appendage, attached in place, is ornamented with a delicate imbrication of raised, leaf-shaped lines, like pointed arches, with a minute tracery of smaller leaf-like pattern within them: all pointing backwards. The same ornament appears on the head or proximal portion of the telson also. The ornament has some resemblance to the pattern on *Eurypterus*; it occurs also on *C. Deweii*, Hall, and on some British forms. This species belongs to Barrande's Stage E e 1 of the Bohemian formations.

From Scandinavia we have seen seven abdominal segments (first and last imperfect), some with the test, some shown only by

[1] Plate VI. will appear in the April Number Geol. Mag.

impressions; crushed laterally, and showing the whole half from the dorsal ridge to the epimeral border. In shape they are not unlike those of *C. Scharyi*, Barrande. They are ornamented with a strong leaf-like lattice-pattern, as in that species. The apices of some of the triangles thicken and form a kind of elongate drop-like ornament (Pl. VI. Fig. 1 *b*). The smaller (secondary) lattice-work inside each leaf-mark is not so distinct as in Barrande's fig. 27.

In hard blue micaceous shale (Ludlow Series), from the lake Ringsjön, Scania.

This specimen is a portion of "fig. 1" in Angelin's unpublished "Tab. B." That figure shows a large portion of the ultimate segment, and the complete penultimate segment; but the former and a third of the latter have been broken away, and a fracture passes between the two next segments.

6. CERATIOCARIS PECTINATA, T. R. J. & H. W. Plate VI.[1] Fig. 2.

1887. *Ceratiocaris pectinata*, sp. nov. Fifth Report, etc. p. 3.

A portion of an ultimate segment (14×6 mm.), with a telson (fragment 30 mm.) and one stylet (not quite perfect, 22 mm.). The segment retains scarcely any of the test, but shows traces of an ornament of irregular small tubercles and interrupted longitudinal lines; and the distal margin of the segment has a coarse comb-like fringe, consisting of a regular set of thin elongate tubercles, reminding one of the drop-like tubercles on marginal parts of some Eurypterids.

The head of the telson is wrinkled longitudinally, and both the style and the stylet are ridged and furrowed. This form being new to us, its comb-like fringe suggested the name *pectinata*.

In earthy micaceous blue-grey limestone, from the Ringsjön, Scania.

This specimen is "fig. 2" in Angelin's unpublished "Tab. B."

EXPLANATION OF PLATE V.

(ALL OF THE FIGURES OF THE NATURAL SIZE EXCEPT FIG. 8 *b*.)

FIG. 1. *Ceratiocaris Angelini*, J. & W. View of the underside of the style and stylets. From a plaster cast. The style is not quite perfect.
„ 2 *a*, *b*, *c*. *Ceratiocaris Bohemica*, Barr. Views of a part of the butt-end of a style. *a*, side view; *b*, dorsal aspect; *c*, section.
„ 3, 4 *a*, *b*; 5 *a*, *b*; 6 *a*, *b*. The same. Dorsal views and sections of portions of styles.
„ 7 *a*, *b*. *C. valida* (?), J. & W. Side view and section of a portion of a style.
„ 8 *a*, *b*, *c*. *C. concinna*, J. & W. Views of a broken style. 8 *a*, dorsal view; 8 *b*, a row of pits, enlarged 2 diam.; 8 *c*, sectional area.
„ 9. *Ceratiocaris*, sp. nov.? View of the underside of a stylet.
„ 10 *a*, *b*. *C. Bohemica*, Barr. View of the underside of a stylet, and its sectional area.

[1] Plate VI. will appear in the April Number of the GEOLOGICAL MAGAZINE.

(*To be continued in our next Number.*)

II.—Further Notes on Carboniferous Selachii.[1]

By Dr. R. H. Traquair, F.R.S., F.G.S.

Anodontacanthus and Pleuracanthus.

In 1881[2] Mr. J. W. Davis proposed the genus *Anodontacanthus* for certain straight spines resembling *Pleuracanthus*, but differing in the absence of the two rows of denticles. Three species are included:—*A. acutus* and *obtusus*, from the Coal-measures of Yorkshire, and *A. fastigiatus*, from the Blackband Ironstone of Carboniferous Limestone age at Loanhead, near Edinburgh.

I offer no criticism on the two Yorkshire species, nor have I seen the type of the Midlothian *A. fastigiatus*. In the large collection of spines which I have from Loanhead, there are, however, many which I refer without doubt to the last-named species. Now, although some of these are smooth and without denticles, others show, in all stages of apparent wearing away, undoubted stumps of denticles, whereby the species *fastigiatus* falls into *Pleuracanthus*, as that genus at present stands.

It is to be noted that a large number of the spines found in this Ironstone (Loanhead and Borough Lee, No. 2) are singularly worn or eroded all over, as if they had been long exposed to the action of agencies, chemical or mechanical, tending to destroy the surface. I have seen a spine of *Gyracanthus* from that bed having every vestige of the surface ornament, so elaborate in that genus, removed, and I had to examine it microscopically before I felt absolutely sure of its genus. Other *Gyracanthi*, etc., are found in every stage of "polishing off." But this phenomenon is by no means peculiar to the spines and other fish remains from Loanhead; it is tolerably frequent elsewhere, and is apt to lead into error those who have not yet learned to take it into account. *Pleuracanthus erectus*, Davis (Q.J.G.S. vol. xxxvi. p. 326), is to my mind nothing but an eroded specimen of *Pl. lævissimus*, Ag., the "very blunt-pointed" character of the denticles being thus amply accounted for, and I have a specimen of *Pl. elegans*, Traq., from Loanhead, which shows precisely the same condition. *Pl. Wardi*, Davis (*ib.* p. 334), probably owes the bluntness of its denticles to the same cause. And I feel pretty well persuaded that T. Stock's *Lophacanthus Taylori* (Ann. and Mag. Nat. Hist. 5th ser. vol. v. p. 217) is nothing but a worn specimen of *Pleuracanthus* (*Orthacanthus*) *cylindricus*, Ag.

Pristodus falcatus, Davis (ex Agassiz MS.).

Mr. Davis, in his large work on the Carboniferous Limestone Fishes of Great Britain, in describing a remarkable tooth to which Agassiz had given the MS. name *Pristodus falcatus*, makes no reference to the fact that a closely allied species had been already, in 1875, figured and described by Mr. R. Etheridge, jun., in the Geological Magazine, under the name of *Petalorhynchus? Benniei*.[3]

Mr. R. Etheridge also mentions that he had been informed by

[1] Read before the Royal Physical Society of Edinburgh, February 15th, 1888.
[2] Q.J.G.S. vol. xxxvii. p. 427.
[3] Geol. Mag. Dec. II. Vol. II. p. 242, Pl. VIII. Figs. 3 and 4.

Mr. W. Davies[1] that Mr. W. Horne had exhibited a similar tooth from Wensleydale at the Bradford meeting of the British Association in 1873, and goes on to say:—"Mr. Davies is also much impressed with its resemblance externally to the uncovered teeth of the Parrot fishes generally, but more especially to the *Diodons*; but as the fish which bore this tooth was undoubtedly a Selachian, and the structure of the tooth, within the mouth, so different to that of the *Diodons*, it can have no affinity with these recent fishes, although very suggestive of a Selachian with a similar form of mouth." This statement as to affinities by Mr. R. Etheridge, jun., cannot be called in question by any one who has studied the structure of the teeth and jaws of *Diodon*; nevertheless, six years afterwards, we find Mr. J. W. Davis, at the British Association in 1881, naming this tooth *Diodontopsodus*, and apparently going back to the idea of its Gymnodont affinities: "In *Diodontopsodus* the teeth are extremely like those of the existing fish *Diodon*" (Proc. Brit. Assoc. 1881, Trans. Sect. p. 646). And in his large work on the Carboniferous Limestone Fishes he seems still unable to free himself from this idea. At p. 521 he says:—"In searching for the zoological relationship of *Pristodus*, a striking and most peculiar resemblance is at once observed between it and some of the Gymnodont group of the Plectognath group of fishes at present existing. . . . In many respects the fossil teeth from the Mountain Limestone of Yorkshire bear considerable resemblance to those of *Diodon*. In the general form of the palatal interior, combined with the semicircular external, trenchant edge of the tooth, the two are almost identical. . . . A comparison of the recent and fossil teeth, however, leads to a natural inference of relationship in some degree, however remote. Evidence is entirely wanting as to the anatomical structure of *Pristodus*, and I do not wish to lead to the inference that it was more nearly related than is warranted by the peculiar similarity of the teeth." I very much fear however that the "peculiar similarity of the teeth" is a very deceptive one after all.[2]

But although *Pristodus* cannot have had the remotest *affinity* with *Diodon*, it is quite an open question as to whether there may not have been some analogy in the form of the jaws, a couple of these peculiar tooth-plates, one above and one below, forming the whole of the armature of the mouth. Rather against this view, however, is the fact that the height of the crown in these teeth is extremely variable, as may be well seen in the extensive series of *P. falcatus* in the British Museum, and that in some the apex is more acute, or tending to be mucronate, than in others.

Mr. J. W. Davis's *Pristicladodus concinnus* seems to me to be nothing more or less than a crushed specimen of a species of *Pristodus* with a more than usually mucronate apex.

[1] Formerly of the British Museum.

[2] My friend Mr. A. Smith Woodward writes to me that he has, from an examination of specimens from Derbyshire, come to the conclusion that *Pristodus Benniei* (R. Eth., jun.) is after all distinct specifically from *P. falcatus*, Ag. *Concinnus* (Davis) he also is inclined to regard as distinct, and in that case all three names will stand as species of *Pristodus*.

Pristicladodus, M'Coy.

There can be no doubt that the specimen from Armagh, in the British Museum, to which Mr. J. W. Davis has given the name of *Carcharopsis Colei*, is nothing else than a specimen of *Pristicladodus dentatus*, M'Coy, with the base broken off.

Chondrenchelys problematica, n. gen. & sp.

Among the fishes from the Eskdale beds, obtained from Mr. Damon for the Edinburgh Museum, is one whose nature is still more problematical than that of *Tarrasius*, which it somewhat resembles in external shape. Two specimens in the Edinburgh Museum have the head and the tail preserved up to near the termination of the latter, and of these the lengths are, respectively, $4\frac{3}{4}$ and 7 inches. The shape of the body is singularly elongated and eel-like, the head being small, less than $\frac{1}{6}$ of the total length, while a long, low, continuous dorsal fin runs along the back from not far behind the head to the end of the slender pointed tail.

In the larger of these two specimens no structure can be made out in the head at all, owing to the obstinacy with which a layer of matrix adheres to the surface.

The smaller affords not much more light as to this part, though the shape of the head appears pointed, and there is some appearance of what is either a mandible or a palato-quadrate arch. It is even difficult to make out whether the substance exhibited be true bone, or calcified cartilage, though there is a spicular-looking body lying longitudinally in the middle of the head, which from its smooth, almost glistening, aspect reminds us of bone. About $\frac{1}{5}$ inch behind the head, and apparently not at all attached to it, is an evident shoulder-girdle, or coraco-scapular arch, whose direction is obliquely downwards and forwards. Careful examination reveals no composition out of distinct membrane-bones; on the other hand, its substance has an unmistakeably granular aspect suggestive of calcified cartilage. No trace of paired fins, pectoral or ventral, is visible.

Commencing at the head, and passing back under the aforesaid shoulder-girdle to the extremity of the tail is a well-marked vertebral column. Here the axis consists of undoubted centra, which are rather higher than long. They are crushed and flattened laterally, but on careful examination of a most instructive fragment in the collection of the Geological Survey of Scotland, they can clearly be made out to have had the configuration of thin-walled hollow rings, through which a scarcely constricted notochord must have passed. Appended to the dorsal aspect of this chain of centra is a series of bodies representing the neural arches and spines. Each of these is short, slender, and rod-like, bifurcating below and pointed above, and there seems to be one for each centrum. They are not composed of ordinary bone, but of small granules placed end to end like a string of beads, and that they had not the rigidity of bone is seen from the flexuosities which they often present in their contour. Commencing almost immediately behind the shoulder-girdle, and appended to the neural spines above, is a second series of rod-like bodies represent-

ing fin-rays or radials, of which there are three or four to each neural spine; they are more slender than the latter, but have the same granular structure. They gradually increase in length towards the posterior third of the body, whence they again fall away towards the end of the tail. The abdominal region extends for 1⅝ inch behind the head: no ribs are visible, the termination of the abdomen being marked by the commencement of a series of hæmal elements quite similar in configuration and structure to the neural ones above, and these now extend to the extremity of the tail. No fin-rays are seen on the ventral aspect of the skeleton, nor have I seen any trace of any dermal hard parts.

This is indeed one of the strangest fishes as yet yielded by these Eskdale deposits, which have proved so rich in palæichthyological treasures. We are not aware of any ganoid, recent or fossil, whose body is entirely destitute of dermal hard parts, for even the all but naked *Polyodon* of the present day and also the Carboniferous *Phanerosteon* have still a few scales on some part of their surface. It seems also scarcely probable, that the apparent absence of membrane bones from the head and shoulder-girdle is entirely due to deficient preservation, and the granular structure of the vertebral apophyses and radials is not paralleled so far as I know in any Ganoid. It certainly is not an ordinary Ganoid, nor is it an Acanthodian. On the other hand, its affinity to the Selachii seems to be indicated by the position of the shoulder-girdle, and by the granular calcification of the vertebral apophyses and radials, and probably also of the head and shoulder-girdle. If it be a Selachian, it is certainly one of a very primitive and at the same time aberrant type. In its long dorsal fin, it resembles *Xenacanthus*, but there is no cephalic spine, apparently no paired fins (though this may indeed be due to defective preservation), the vertebral centra are more developed, and the two rows of dorsal interspinous cartilages or "Flossenträger" described by Kner in that genus seem to be absent. It is certainly a new, as well as a most interesting form, for which I accordingly propose the name of *Chondrenchelys problematica*.

III.—On the Detection of Mural Pores in thin Sections of the Favositidæ.

By H. Alleyne Nicholson, M.D., D.Sc., F.G.S.,
Regius Professor of Natural History in the University of Aberdeen.

As a text for the following brief remarks on the recognition of mural pores in thin sections of the Favositoid Corals, I may quote a note appended by Mr. James Thomson, F.G.S., to a recent paper on the genus *Lithostrotion* (Trans. Edin. Geol. Soc. vol. v. part iii. p. 381). The note in question is subjoined, the quotation being *verbatim*, and, I may add, *literatim* also:—

"We may, however, attach an undue importance to microscopic examinations. Need I refer to the point raised recently by that erratic and energetic worker, Prof. Alleyne Nicholson, regarding mural pores in the genus *Alveolites*, the type of which is also in Dr.

Fleming's collection. If he had detected mural pores in microscopic sections, we would have regarded such as being one of the greatest discoveries of modern times. Is it to be expected that such delicate pores could retain their normal aspect, surrounded and impregnated by induced calcareous matter during fossilisation? Indeed, we have failed in detecting the mural pores in the genus *Michelinia* by the microscope, which is of gigantic proportions in comparison to any of the four species of *Alveolites*. In, however, weathered specimens of either we find no difficulty in detecting the mural pores, and in no locality have we procured better examples showing such than is to be found in the examples of *A. depressa*, found in Charleston Quarry, Fifeshire. A variety of *Alveolites*, which we believe has been rashly relegated to the genus *Chœates hyperbolus*,[1] by Nicholson and Etheridge, jun."

So far as concerns the genus *Alveolites*, Lam., in particular, it is unnecessary to criticise the statements contained in the above note; since the note itself contains the plainest proof that Mr. Thomson does not know what the genus *Alveolites*, Lam., *is*, and that he is not acquainted with any species of the same. The first point is sufficiently shown by his assertion that "the type" of the genus is "in Dr. Fleming's collection"; whereas the type of the genus *Alveolites*, as every palæontologist knows, is the familiar *A. suborbicularis*, Lam., of the Devonian rocks, and is preserved at Paris. The second point is equally clear from his speaking of "the four species of *Alveolites*," as if there were only four species in the genus; the truth being that "the four species" to which he refers (viz. *Chætetes septosus*, Flem., *C. depressa*, Flem., *C. capillaris*, Phill., and *C. Etheridgii*, Thoms.) belong to the genus *Chætetes*, Fischer, and are not referable to the genus *Alveolites*, Lam., at all.

As regards the general question involved, in view of all that has been published in recent times as to the minute structure of the Favositoid Corals by Ferd. Roemer, Lindström, Schlüter, Frech, Foord, R. Etheridge, jun., the present writer, and others, it is difficult to believe that one who professes to have studied Palæozoic Corals should speak of the recognition of mural pores in thin sections of *Alveolites* as still unaccomplished,[2] or of its possible accomplishment as being "one of the greatest discoveries of modern times." Even in the days of those great masters—Milne Edwards and Haime—before the method of working by means of thin sections had come into use at all—it was a familiar fact that mural pores could readily be recognized in polished slabs of the Favositoid Corals. Mr. Thomson does not appear to have grasped the elementary fact

[1] By "the genus *Chœates hyperbolus*" Mr. Thomson refers, I presume, to the "species" described by Mr. R. Etheridge, jun., and myself, under the name of *Chætetes hyperboreus*.

[2] Mr. Thomson's disbelief in the possibility of recognising mural pores in thin sections of the Favositoid Corals is, it may be noted, of comparatively recent growth. Thus, in a paper published in the Proceedings of the Philosophical Society of Glasgow in 1881, Mr. Thomson described and figured what he believed to be mural pores in thin sections of *Chætetes Etheridgii*, Thoms. sp. A reference to his figure (*loc. cit.* pl. i. fig. 7) will show, however, that in this case the supposed "mural pores" are represented *in the centre of the calcite filling the visceral chambers of the corallites*, and that they are really nothing more than minute granules of calcite.

that whatever is shown by a polished vertical or horizontal slice of a Coral will necessarily be shown by corresponding thin sections. A thin section often shows *more* than a polished slab, but never *less*. Every one who has ever examined polished specimens of such common Devonian species of *Alveolites*, as *A. suborbicularis*, Lam., *A. Battersbyi*, E. & H., or *A. reticulata*, E. & H., knows that such, as a rule, exhibit the mural pores with the utmost clearness. This being the case, it follows, as a matter of course, that thin sections of such forms show the mural pores, to one who knows what to look for, with at least equal clearness. What is true of the above-mentioned forms is true of the Favositoid Corals generally, in thin sections of which mural pores can usually be detected without any difficulty. This assertion is not at all affected by the fact that in certain states of mineralization any form of the *Favositidæ may* fail to yield direct evidence of mural pores, when examined either in polished slabs or in thin sections.

The phenomena by which we may recognize in thin sections of the Favositoid Corals the presence of mural pores are, of course, well known to palæontologists generally. For the benefit, however, of those who may be beginning the study of the fossil Corals by means of thin sections, I may briefly indicate the character of these phenomena.

In the first place, it is to be remembered what "mural pores" are. In their typical form, mural pores are simply rounded or oval apertures, arranged in longitudinal series, which perforate the walls of adjacent corallites and place adjoining visceral chambers in direct communication. In some cases, the "mural pore" is not completed; since the thin "primordial wall" which separates adjacent tubes is not actually perforated, but is continuous. In such cases, the cavities of adjacent tubes do not actually communicate, and the so-called "mural pore" is simply caused by a deficiency, at corresponding points, of the thick layer of secondary sclerenchyma ("stereoplasma") which ordinarily coats both sides of the "primordial wall." In other cases, again, as in the genus *Roemeria* and in the typical species of *Pachypora*, where the above-mentioned layer of secondary sclerenchyma is excessively thick, the "mural pores" assume the character of longer or shorter *tubes* which connect adjacent visceral chambers. Whatever may be the precise form assumed by the mural pores, they can usually be readily recognised in thin sections, whether these sections be taken at right angles to the tubes or in a direction corresponding with the long axes of the latter. The facility with which they can be detected depends partly upon the condition of preservation of the specimen examined and partly upon the size and arrangement of the mural pores themselves. With regard to the latter point, the large, often uniserial pores of forms like *Alveolites* and *Pachypora* are usually more conspicuous than the generally smaller, often biserial or triserial pores of *Favosites* and its immediate allies.

Bearing the nature of "mural pores" in mind, it is easy to recognize the phenomena which they present in thin sections.

1. *Tangential Sections.*—Sections taken tangentially to the surface of a Favositoid Coral, so as to cut the corallites at right angles to their length, very commonly exhibit the mural pores. In such cases the mural pore presents itself as a gap in the wall forming the circumference of a corallite (Fig. 1, *A*, *B*, and *C*, *p*), the size of this gap depending upon the size of the pore. If the mural pore is not a complete perforation (as sometimes happens), then the gap is crossed by the thin primordial wall of the corallite, the delicate partition thus formed being uncovered on both sides by the layer of

Fig. 1.

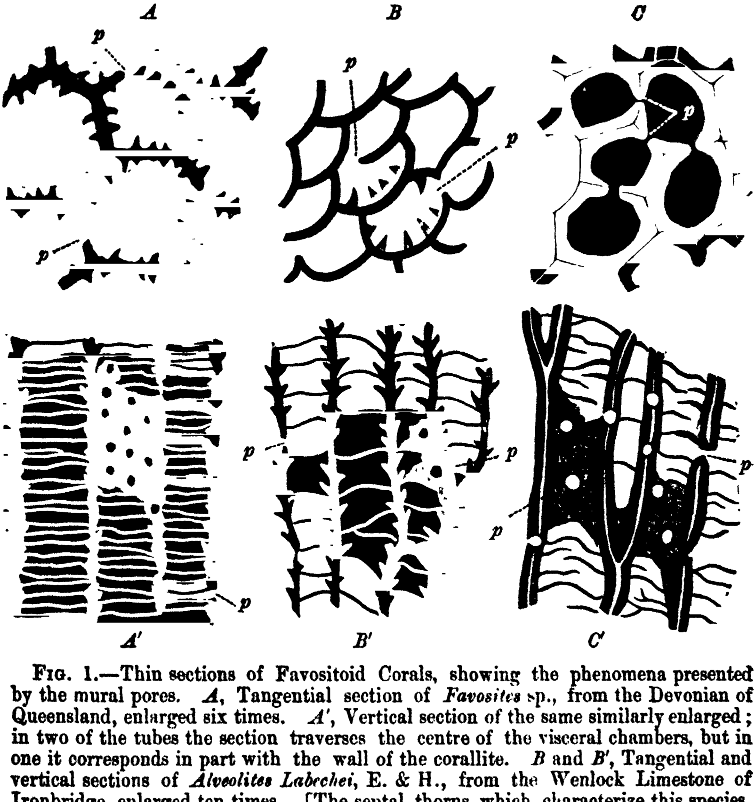


Fig. 1.—Thin sections of Favositoid Corals, showing the phenomena presented by the mural pores. *A*, Tangential section of *Favosites* sp., from the Devonian of Queensland, enlarged six times. *A′*, Vertical section of the same similarly enlarged; in two of the tubes the section traverses the centre of the visceral chambers, but in one it corresponds in part with the wall of the corallite. *B* and *B′*, Tangential and vertical sections of *Alveolites Labechei*, E. & H., from the Wenlock Limestone of Ironbridge, enlarged ten times. [The septal thorns which characterize this species, as also *A. Battersbyi*, E. & H., are mostly omitted in the drawing.] *C* and *C′*, Tangential and vertical sections of *Pachypora* sp., from the Corniferous Limestone of the Falls of the Ohio, enlarged ten times. In all the figures the letter *p* indicates the mural pores.

secondary sclerenchyma which elsewhere lines the wall. In the great majority of well-preserved specimens of species of *Favosites*, *Pachypora*, *Striatopora*, *Michelinia*, *Pleurodictyum*, *Alveolites*, etc., there is usually no difficulty in recognizing the presence of mural pores by the more or less frequent occurrence in tangential sections of the deficiencies in the walls of the corallites above described. In

Alveolites itself, the mural pores are generally uniserial, and are placed along the *short* sides of the compressed corallites; so that they appear in tangential sections as gaps at the *ends* of the crescentic tubes (Fig. 1, *B*). It is hardly necessary to add that a tangential section is very unlikely to traverse more than an *occasional* mural pore. It is, therefore, only here and there in such a section that we should find the deficiencies in the walls of the corallites due to the presence of mural pores; and in some sections we might fail to find any traces of the pores.

The only appearance which, so far as I know, could be confounded with the above is the apparent communication between two adjacent corallites seen in tubes of *Chætetes*, and of certain other types, as viewed in tangential sections. In these latter cases, however, it is not that *two* adjoining corallites are placed in communication by a perforation in their wall, but that *one* corallite is imperfectly separated into two by the extension into the visceral chamber of a septiform plate, the result of commencing fission. It is hardly possible for a practised observer to confound the appearances produced in this way with those due to the presence of mural pores; and in any case an examination of longitudinal sections would at once show the true nature of the phenomenon.

2. *Vertical sections traversing the visceral chambers of the corallites.*—Vertical sections of the Favositoid Corals—*i.e.* sections cutting the tubes longitudinally—usually in part traverse the *visceral chambers* of the corallites, while in part they coincide more or less closely with the *walls* of the corallites. In the former case, the section exhibits the infilling of the tube (calcite or mud), intersected by the tabulæ and bounded laterally by the longitudinally divided wall of the corallite on each side (Fig. 1, *A′*, *B′*, and *C′*). In such cases, the presence of mural pores can commonly be recognized by the more or less frequent occurrence of gaps or deficiencies in the wall on each side, the cavity of the tube being thus placed in communication with adjoining visceral chambers. The phenomena presented in these cases are precisely similar to those shown in tangential sections, and need no special notice. As in the latter, it is only here and there that the line of section happens to coincide with a mural pore, and it is, therefore, only here and there that we observe in long sections the gaps in the bounding-walls of the corallites caused by the presence of pores, the size and number of these gaps depending directly upon the size and number of the pores. As a rule, however, the presence of mural pores can in this way be readily recognized in thin vertical sections of *Favosites, Michelinia, Pachypora, Alveolites,* and the other Favositoid Corals (see Fig. 1).

For obvious reasons, longitudinal sections which more or less closely coincide with the centre of the visceral chamber of a corallite cannot exhibit any signs of mural pores other than the gaps just mentioned in the bounding-walls of the tube. In other words, no trace of the mural pores can be found in the calcite or mud which occupied the space between the bounding-walls. It is not uncommon, however, to find certain structures in the calcitic infilling of the

corallite which may readily be mistaken for mural pores. The structures to which I allude present themselves as rounded dark dots arranged in lines, and presenting very much the appearance of being pores. In reality, these structures—which have sometimes been confounded by various observers (including myself) with mural pores—are the cut ends of septal spines or thorns, which project into the cavity of the corallite, and thus come to be divided in sections across the visceral chamber.

3. *Vertical sections coinciding with the walls of the corallites.*—As above mentioned, most vertical sections of the Favositoid Corals come here and there to traverse the *walls* of the corallites. This is inevitable when we reflect that the corallites are usually more or less curved, so that it is hardly possible for a vertical section to divide any single corallite along its whole length in a single plane. Hence, a section which in one place cuts a tube through the centre of the visceral chamber may in another place divide the same tube along one of its bounding-walls (see Figs. 1 *A′ B′* and *C′*). Whenever the plane of a vertical section comes to coincide with the plane of the wall of a corallite, the mural pores are necessarily shown more or less extensively as round or oval perforations in the wall, the latter appearing as a more or less opaque space replacing the calcitic infilling of the visceral chamber (Fig. 1 *A′*). Almost all vertical sections of well-preserved examples of *Favosites*, *Pachypora*, *Michelinia*, *Alveolites*, etc., show the appearances here described at certain points; and when this is the case, the presence of mural pores can never be doubted. In certain species of *Favosites*, however, as for example in *F. aspera*, D'Orb., and *F. Mullochensis*, Nich. and Eth. jun., vertical sections may fail to show the mural pores, owing to the fact that these openings are placed at the *angles* of the prismatic tubes, instead of along the *flat faces* of the corallites. In the species of *Alveolites*, also, owing to the position of the pores on the *short sides* of the corallites, vertical sections often fail to show the appearances just described, since the parts of the wall exposed in such sections commonly belong to the *wide non-poriferous faces* of the corallites.

If an investigation of a coral otherwise similar to the *Favositidæ* should fail to bring to light any of the phenomena above described as indicating in thin sections the presence of mural pores, it may in general be safely concluded that such a Coral is "imperforate." At the same time, it is not safe in all cases to conclude that mural pores are wanting merely because their presence has not been detected in one or two thin sections. There are plenty of cases where a single thin section exhibits no traces of mural pores, but where abundant evidence of the presence of these structures can be obtained by an investigation of a *series* of such sections. There are also cases where a specimen of a form certainly known to possess mural pores may nevertheless fail to show signs of these in thin sections, as the result of complete recrystallization or replacement. Such cases are, however, rare, and do not affect the general value of the characters above pointed out.

In conclusion, I may add that I have carefully examined a very extensive series of thin sections of the four types of Carboniferous Corals which Mr. Thomson speaks of as "the four species of *Alveolites*," and I have failed to find in a single instance any indication of any of the phenomena above mentioned as caused by the presence of mural pores. I have therefore no doubt that the corallites in these four types possessed imperforate walls; while the general structural features which they present render it certain that they are truly referable to the genus *Chætetes*, Fischer.

IV.—Notes on Tertiary Lacertilia and Ophidia.

By R. Lydekker, B.A., F.G.S., etc.

A RECENT examination of the remains of Tertiary Lacertilia and Ophidia preserved in the British Museum having brought to light some new facts in regard to distribution, and also indicating the necessity of revision of certain determinations of other authors, I have thought it advisable to communicate the result of my observations in a collective form.

Iguana.—In his description of the vertebrates of the Quercy Phosphorites Dr. Filhol[1] describes and figures two fragments of the jaws of a small Lizard which he refers to the American genus *Iguana*, under the name of *Iguana europeana*, although in the description of the plate[2] they are mentioned as *Proiguana*. Among the Hastings collection from the Upper Eocene (Oligocene) of Hordwell in Hampshire I find several vertebræ (No. 32840, A) of a small Lizard, which show the minute zygosphenes characteristic of the *Iguanas*, and agree in all other respects with the vertebræ of existing forms. I have, therefore, no hesitation in referring these specimens to the *Iguanidæ*; and since (as I shall again have occasion to mention) at least a certain proportion of the Hordwell and Quercy Squamata appear specifically identical, I think it is not impossible that these specimens may belong to *I. europeana*. With regard, however, to the reference of this species to the genus *Iguana*, it will, of course, be necessary to use that term in a much wider sense than in recent herpetology, where it is restricted to two species; but if the type European form be eventually found decidedly different, the name *Proiguana* might be adopted. The occurrence of such an essentially American type in the European Tertiary is paralleled by the occurrence in the Œningen beds of the genus *Chelydra* among the Chelonia; and also of *Latónia* among the Ecaudata, which is closely allied to, if not identical with, the Brazilian *Ceratophrys*.

Placosaurus.—In his "Zoologie et Paléontologie Françaises," 2nd ed. p. 260, pl. lxiv. fig. 2, the late Prof. P. Gervais described and figured part of the cranium of a Lizard from the Upper Eocene (Lower Oligocene) of Vaucluse under the name of *Placosaurus rugosus*; of which the most characteristic feature is the presence of an armour of sculptured polygonal dermal scutes on the upper surface. Many years later the same writer in his "Zoologie et Paléontologie

[1] Ann. Sci. Géol. vol. viii. p. 267. [2] *Op. cit.* p. 338.

Générales," sér. 2, p. 60, gave a woodcut of the cranial scutes of another Lizard from the approximately equivalent Phosphorites of Quercy under the name of *Varanus margariticeps*, making, however, no reference whatever to *Placosaurus*. Now if the type specimens of these two forms be compared together, there cannot, I think, be much hesitation in acknowledging their generic identity; while it is perfectly clear from the presence of dermal scutes that they have nothing whatever to do with the *Varanidæ*. At a still later period Dr. Filhol[1] described and figured from the Quercy Phosphorites an imperfect dentary bone under the name of *Palæovaranus cayluxi*, and suggested that it might be the same as the so-called *Varanus margariticeps*; but since this specimen appears to belong to a true *Varanus*, it will be perfectly distinct from the latter. In the collection of the British Museum I find, however, a number of vertebræ belonging to Lizards of medium dimensions, from Quercy (No. R. 428), and also others of similar type from Hordwell (No. 32840), which agree most nearly with those of certain existing genera of *Anguidæ*, and appear decidedly distinct from those of the *Varanidæ*, although there is a great general resemblance between the vertebræ of the two families. This would lead to the conclusion that since *Placosaurus* agrees with the *Anguidæ* in the presence of dermal scutes, the vertebræ in question belong to the Quercy species of that genus. I find, moreover, a dentary bone of a Lizard from Quercy (No. R. 377) agreeing very closely with the dentary of the existing genera *Diploglossus* and *Ophisaurus*; and the presumption is therefore very strong indeed that this specimen is likewise referable to the Quercy *Placosaurus*. It appears, however, to be indistinguishable from a fragmentary dentary from Quercy figured by Dr. Filhol in pl. xxvi. fig. 425 of the work cited under the name of *Plestiodon* (= *Eumeces*) *cadurcensis*; that genus belonging to the family *Scincidæ*. That the present specimen is, however, not a Scincoid is decisively shown by the absence of the descending ridge from the coronoid on the outer aspect of the posterior extremity of the dentary, which forms such a characteristic feature in that family. Finally, on comparison of a Quercy femur (No. R. 387) with the similar specimen figured by Dr. Filhol (*op. cit.* pl. xxvi. figs. 445–446) under the name of *Palæovaranus*, I find a marked resemblance to the femur of the Anguoid genus *Diploglossus* and a wide difference from that of *Varanus*.

The foregoing evidence tends therefore to show that all the above-mentioned specimens are in all probability referable to the genus *Placosaurus*; which accordingly appears to have been a member of the *Anguidæ* provided with well-developed limbs. There is no evidence to show whether the Quercy form is really distinct from the typical Vaucluse *P. rugosus*; but for the present it may perhaps be advisable to retain the specific name *margariticeps*, of which *Plestiodon cadurcensis* appears to be a synonym. The Hordwell form may belong to either the Vaucluse or the Quercy representative of the genus, if these be distinct. And I may add that the North American

[1] *Op. cit.* p. 268, pl. xxvi. fig. 434 (1877).

Eocene genera *Saniva*, Leidy, and *Glyptosaurus*, Marsh, are in all probability closely related to *Placosaurus*.

Paleryx and *Palæopython*.—The genus *Paleryx* was founded in 1850 by Sir R. Owen[1] on the vertebræ of a comparatively large snake from the Hordwell Beds, which was regarded as nearly allied to the existing genus *Eryx*. In 1880 M. Rochebrune[2] described and figured certain Ophidian vertebræ from the Quercy Phosphorites under the new generic title of *Palæopython*; identifying one species with *Python cadurcensis* of Dr. Filhol,[3] and naming a second species *Palæopython Filholi*. On comparing vertebræ from Quercy in the Museum (No. R. 428, A) which are indistinguishable from the specimen figured by Rochebrune as *Palæopython cadurcensis* with the type vertebra of *Paleryx rhombifer* (No. 25259), I find that the two cannot be even specifically distinguished. Similarly I find that smaller vertebræ from Quercy (No. R. 428, D) agree precisely with the types (No. 25261) of the Hordwell *Paleryx depressus*, Owen; and I believe that these are in all probability specifically identical with slightly larger Quercy vertebræ (No. R. 428, C), agreeing with the type of *Palæopython Filholi*, Rochebrune. It appears, therefore, that the genus *Palæopython* is identical with *Paleryx*, and should accordingly be abolished; but I agree with M. Rochebrune in regarding the vertebræ to which this name was applied as indicating a Snake very closely allied to *Python*, and clearly referable to the same family.

Palæophis.—The vertebræ of huge Serpents from the London and Bracklesham Clays, described by Sir Richard Owen in the memoir above cited as *Palæophis*, were regarded by him as allied to the marine *Hydrophidæ*. Other vertebræ of similar structure were subsequently obtained from marine Eocene beds in North America, and described by Prof. Marsh under the name of *Titanophis* (*Dinophis*), although regarded by Prof. Cope as generically indistinguishable from *Palæophis*. Both these writers suggested that these Serpents were more nearly allied to the *Pythonidæ* than to the *Hydrophidæ*; and in the memoir which I have already quoted M. Rochebrune came to the conclusion that they should be included in the *Pythonidæ*. If, however, the vertebræ of *Palæophis* be compared with those of *Python*, it will be seen that they differ by their much taller neural spine, by the lower position and different contour of the costal articulation, by the much less prominent zygapophyses, by the more developed hæmal carina, as well as in several minor features; and it would thus appear that on osteological grounds alone the reference to the *Pythonidæ* cannot be maintained. This inference is, however, supported by other considerations. Thus the existing Pythons are confined to the Old World and Australia; and, although they can and do swim well in freshwaters, they are essentially land snakes. Judging, however, from the strata in which *Palæophis* and *Titanophis* occur, there is a very strong presumption, as Sir R. Owen and Prof. Marsh have pointed out, that

[1] Reptilia of London Clay (Mon. Pal. Soc.), pt. 3, p. 67.
[2] Nouv. Archiv. d. Muséum, ser. 2, vol. iii. p. 277, pl. xix.
[3] Ann. Sci. Géol. vol. viii. p. 270 (1877).

these Serpents were of marine habits; and the occurrences of closely allied, if not generically identical, forms on both sides of the Atlantic tends to confirm this view. In addition, therefore, to the osteological differences between *Palæophis* and the *Pythonidæ*, we have in all probability to add the difference of marine against terrestrial habits; and these two differences appear to me to leave little doubt as to the right of the former genus to represent a distinct family type—the *Palæophidæ*. There is, unfortunately, no skeleton of *Hydrophis* accessible to me for comparison with *Palæophis*, but since M. Rochebrune states that the vertebræ of the former are widely different from those of the latter, I think, for the present at any rate, it will be advisable to retain the *Palæophidæ* among the true Colubriformes, where they may be placed after the *Pythonidæ* and allied families.

In conclusion I may observe that figures of some of the specimens I have here mentioned will be given in the British Museum Catalogue of Fossil Reptilia and Amphibia, where attention will be somewhat more fully directed to the question of the specific identity of some of the forms to which I have alluded.

V.—On the Effect of Continental Lands in Altering the Level of the Adjoining Oceans.[1]

By Professor Edward Hull, LL.D., F.R.S.,
Director of the Geological Survey of Ireland.

THE effect of the attraction of continental land upon the oceanic waters adjoining seems to have been very much overlooked by British physical geographers. That some slight effect arises in the direction of elevating the surface of the ocean in proximity to the coast is generally admitted, but the amount of rise is considered to be small, perhaps insignificant. The prevalence of these views was attributed by the author to the widespread influence of Lyell's hypothesis of the uniformity of the ocean-surface all over the globe.

The author's attention had been called to the subject by the perusal of the works of the German geographers Suess[2] and Fischer,[3] especially the latter; and he had received great assistance in his investigations from Professor G. G. Stokes, M.P., Pres.R.S., and from the Rev. Maxwell H. Close, F.G.S., which assistance he gratefully acknowledged.

In attempting to determine the relative levels of the ocean-surface along the margins of continents as compared with those of mid-oceanic islands, the German authors above quoted had based their results on observations of the length of the second's pendulum. Many years ago (1849) Stokes had shown that the force of gravity must be greater in such islands than on continental stations,[4] and

[1] The paper will probably be published *in extenso* in the Scientific Transactions of the Royal Dublin Society (1888).
[2] Suess, *Das Antlitz der Erde* (1887).
[3] Fischer, *Untersuchungen über die Gestalt der Erde* (1886).
[4] Stokes, *Cambridge Philosophical Transactions*, vol. viii. pp. 672–695.

this conclusion corresponded with actual observations on the length of the second's pendulum at stations all over the globe as tabulated by Airy.[1] The formula of Suess and Fischer based on these was to the effect that the difference in the level of the ocean between two such stations was found in *mètres* by multiplying the difference in the number of daily oscillations in the second's pendulum by 122. This in the case of the stations of California (or Mexico?) in lat. 21° 30′ and of the Sandwich Islands would amount to 4520 feet: a very startling result if correct.

The author proceeded to discuss the effect of continental lands, showing that this was in the first instance divisible under two principal heads: The effect (1) of the unsubmerged, and (2) of the submerged masses. In the former case (*i.e.* where the mass rose above the surface), one component of the attraction acted in a more or less vertical direction; in the second case, all in a lateral direction; but both had the effect of elevating the surface of the ocean. The horizontal distance to which the vertical effect extended owing to the curvature of the earth's surface was then considered; and it was shown that, where continental lands rise from a deep ocean, the effect of the lateral attraction far exceeds that of the vertical attraction of the unsubmerged mass. Professor Stokes had furnished the author with a hypothetical case, in which the elevation of the ocean was estimated to reach 400 feet above the mean geodetic surface of the earth.

For the purposes of illustration three cases were selected, viz.:—

(1) The table-land of Mexico,	between lats.	18° and 26° N.
(2) The table-land of Bolivia,	,,	19° and 25° S.
(3) The Andes of Chile,	,,	26° and 35° S.

The mean elevations, distances from the ocean, and extent having been determined, and the mean density of the crust being taken at 2·6 for emergent, and 1·6 for submerged, land, the results of the attraction of the mountain masses in each case were as follows:—

(1) Mexico, 230 feet; (2) Bolivia, 301 feet; (3) Chile, 63 feet; the elevations being calculated above a mean geodetic surface.

To the above results, due to the gravitation-potential of the elevated masses, were to be added those due to the following factors:—

(*a*) The marginal plain or emergent tract on either side of the mountain mass.
(*b*) The high lands both to the north and south of the special sections above dealt with.
(*c*) And lastly, and most important, the submerged continental mass.

To provide for the sphericity of the earth deductions of various amounts, according to circumstances, were made from the numbers obtained from the formula which Mr. Close had arrived at by a double process, and which is given at length in the paper itself.

Combining these results with those given above, we obtain as the whole rise of the ocean surface as follows:—

(1) Mexico, 780 feet; (2) Bolivia, 2159 feet; (3) Chile, 1582 feet.

In all the above cases the coast was taken as descending to a

[1] Airy, "On the Figure of the Earth," *Encyclop. Metropolitana.*

depth of 15,000 feet at a gradient of about $\frac{1}{14}$ to $\frac{1}{16}$, the comparatively low results in the case of Chile being due to the narrowness of the mountain range, 30 miles in mean breadth, as compared with 300 miles in the case of Bolivia.

The above results, which are probably rather under than over estimates, fall considerably short of those to be drawn from Suess and Fischer's formula, but are probably much in excess of the views held by British physical geographers generally; and the conclusion was drawn, that if the same processes of reasoning and calculation were applied to all parts of the world, it would be found that the ocean waters are piled up to a greater or less extent all along our continental coasts, producing very important alterations in the terrestrial configuration as compared with an imaginary ellipsoidal, or geodetic, surface, to which all these changes of level must necessarily be referred.

VI.—The Occurrence of Variegated Coal-measures, Altered Ironstones, etc., at Swadlincote, Derbyshire.

By W. S. Gresley, F.G.S.

A HIGHLY interesting and remarkable instance of altered Coal-measures, due to impregnation by hydrous and anhydrous oxides of iron, infiltrated by water from the overlying Permian strata, can now be seen *in situ* in the Ashby-de-la-Zouch Coal-field, and I think it should be made known in order that those who may wish to study such phenomena may have the opportunity of doing so. The following is a general description of the section.

The section may be seen near the Fire-brick and Pipe Works of Messrs. Wragge, at Swadlincote, near Burton-on-Trent. The exact locality is where the words "Round Wolds" occur half a mile east of Swadlincote, near bottom left-hand corner of Quarter-sheet No. 71 S.W. (Nottingham) of the One-inch Ordnance Survey. It is referred to on page 203 of Mr. H. B. Woodward's new work on "The Geology of England and Wales." It exhibits, in my opinion,

1. Four distinct systems or periods of strata, viz. Carboniferous, Permian, Trias, and Drift. Of the lowermost group of these rocks we have about 40 feet of Coal-measures, consisting of two thin coal-seams; four or five beds of fire-clay, three of which measure about 26 feet in the aggregate, and immediately below the Permians are variegated coal-shales with numerous nodules, and one or two bands of a variety of red hæmatite, and an occasional large concretionary mass of altered siliceo-ferruginous sandstone with cone-in-cone structure.[1]

The Permian strata appear to consist of dark red compact marl, some thin bands of tea-green marl, and a bed of semiconsolidated breccia, containing a variety of crystalline, slaty, igneous, and other rock-fragments.[2]

Upon these lie yellowish soft sandstones, flaggy beds, marls,

[1] See Geological Magazine, No. 1, p. 17, January, 1887.
[2] See Geological Magazine, Vol. for 1885, p. 333.

and a few quartz pebbles, and capping the whole is a rubble of sandstone fragments, layers of sand, a red marly clay with derived pebbles, and soil to surface.

The total thickness of strata at present exposed is about 70 feet, but other beds come in, and can still be seen, between the variegated Coal-measures and the Permians, about 300 feet further to the north.

Each of the above series lies unconformably upon the one beneath it; the Coal-measures have a north-easterly dip; the Permian beds dip east; the Trias lies nearly horizontal, and the Drift overlaps the whole, though it appears only locally.

SECTION AT SWADLINCOTE, DERBYSHIRE.

		Ft.	In.
Drift	Surface soil	1	0
	Red clay, sand, and fragments of sandstone	3	0
Trias	Green and red marly layers	1	0
	Soft sandstone, with layers of yellow and red marl	3	0
	Yellow sandstone, with a few quartzite pebbles at base	9	0
Permian	Light yellow sandstone	2	0
	Semiconsolidated breccia (sometimes in two beds)	4	0
	Red marl, with greenish layers top and bottom	3	6
Coal-measures	Highly-variegated argillaceous shale[1] with band and many flat fossiliferous nodules of red hæmatite, and a few large concretions of yellow and red siliceo-ferruginous sandstone, exhibiting cone-in-cone structure, etc.	8	0
	Dark blue shale without nodules, but sometimes with red veins or joints	3	0
	Coal-seam—sometimes iridescent		10
	Dark fire-clay	2	6
	Lighter ditto—locally called "the marl"	7	6
	Dark clay		6
	Strong grey blocky fire-clay—"the fire-clay"	8	0
	Hard dark shaly clay	1	2
	Coal-seam	1	3
	Inferior fire-clay	3	0
	Hard black clay		3
	Strong inferior fire-clay with nodular clay-ironstone much wrinkled on surfaces	8	6
	Floor of quarry[2]	71	0

Now, the principal point of interest in the above section is the uppermost bed of the Coal-measures—the 'bind' or argillaceous shale with its accompanying concretionary ironstones and large balls of altered 'cankstone.' Where this stratum is in contact with the red beds of the newer rocks, its colour becomes entirely changed, and the great variety of hues of red, brown, purple, yellow, blue, etc., together with the often very curious and remarkably beautiful way in which the alternations, blendings and arrangements of form have been produced, is in itself quite a study. The ironstones, too, certainly deserve attention. When the shale is variegated or mottled,

[1] Owing to unconformity the thickness of this stratum varies a good deal, and in places where the distance between the Permian marl and it, is much increased, the ironstone nodules are found in their natural condition (clay-carbonates).

[2] The section not having been carefully measured, the thicknesses here given are only approximate.

these are invariably found to be of a red hæmatite, more or less compact, and with the nuclei often of limonite more or less soft. These nodules of hæmatite were originally clay-ironstone before the Coal-measures were overlaid by the Permian beds. Of this I entertain no doubt, and in this very quarry may be seen the same nodules in their former condition. That these nodules in their normal state have a peculiar chemical composition not possessed by ordinary sphærosiderite of the Coal-measures seems highly probably from the fact that in weathering they sometimes become a deep red colour, and at others quite yellow. This alteration is always accompanied by a softening of the nodule, with reduction in weight.

At a few yards to the south of the section given above, we find the red-staining from the Permian marl has extended to the Fire-clays beneath the 10-inch bed of Coal, giving them a somewhat similar variegated aspect (though the colouring is less vivid) to the shales above. The red hæmatitic character of the ferruginous nodules occurring in these clays shows also the change they have undergone since Carboniferous times.

In this section too may be seen instances of faulting. We have a dislocation caused *since* the Triassic beds were deposited (where good examples of *slickensides* occur); also one in these beds but not descending to the Coal-measures—a small 'doubling' or overlap fault in the Permian marls, and contorted denuded surface of Coal-measures. The Coal-measures are highly inclined. It may be well here to note that some interesting examples of contorted coal and of 'overlap' faults are to be seen in the neighbouring open-hole workings to the south, notably in those of Messrs. Ensor & Co., The Pool Works, Woodville.

Varieties of Coal-measure clays, and of the other clay-ironstone nodules, of 'peacock,' or iridescent coal, and of Coal-measure fossils (marine? mollusca, coprolites, etc.), may also be obtained: in short, the section exposed probably exhibits as great a number and variety of geological and mineralogical details as could be found anywhere within so limited an area.

There are within half a mile or so of this exposure several other interesting sections of some of the same beds, and of others besides, which could scarcely fail to repay a visit; but, as the excavations go on rapidly, and with strata lying so unconformable as these do, the geological details are always changing; in fact the variegated shale with hæmatite in Wragge's section is rapidly thinning out, or else being obliterated by debris thrown back, or by land-slips.

VII.—Palæontological Nomenclature.

By S. S. Buckman, F.G.S.

The remarks made by Mr. Haddow in the Geological Magazine, Decade III. Vol. IV. p. 519, seem to demand a reply.

1.—He complains of the multiplication of generic or subgeneric names of *Ammonites*.

2.—He laments the confusion which appears to have arisen concerning what have hitherto been regarded as recognizable species.

3.—He suggests that the trinomial system would obviate the necessity of any of these changes and be at the same time an advantage.

In regard to the first point, I would remark that probably no change of any kind, however necessary, can be made without disturbing those who have been accustomed to other ways, and therefore, it is right that those who make these changes should give some reason for so doing. It can be urged that scarcely has the sound of the protests raised against the subdivision of the genus *Ammonites* died away, but the proposal to still further subdivide the subdivisions is started. and everything is again unsettled. But I would ask if palæontology is to follow, and be subject to, the same laws and conditions which govern other sciences, viz. entomology, botany, etc.? Is a genus to be considered as a name for a series of species having certain characteristics in common which at the same time separate it from other series? Is it not wrong to include in the same genus species descended for a long time through entirely different lines of ancestors? But do the present generic names satisfy these conditions? Does *Harpoceras*, which included such very different *Ammonites* as *bifrons*, *insignis* and *Levesquei*, i.e. *Ammonites* descended from the old families *Arietes*, *Armati*, and *Natrices*, of the Lias, fulfil the conditions of a genus? It cannot; and, therefore, I contend that it is necessary that the range of a genus should be narrowed. I place in the same genus *Ammonites bifrons* and *Levisoni* which agree in being very evolute, in having an identical suture-line, and quadrangular whorls with furrows on each side of a solid carina, but differ from each other specifically by a persistent but slight difference in ribbing. On the other hand, I decline to put into that genus *Ammonites* which have sagittate whorls, a different suture-line, and a hollow carina. As regards the difficulty of remembering all these names, I would point out that this is no more than we meet with in other sciences, and any disadvantage in this way is fully compensated by the advantage that we obtain by expressing a definite idea regarding a certain number of species. The number of genera in other sciences gives us sufficient excuse. For instance, in the division *Geometers* of the *Lepidoptera* we find, in Britain, about 200 species divided into 17 families and 88 genera.

Concerning the second part of Mr. Haddow's letter, I do not consider myself to blame for the confusion of which he speaks. He asks whether the "well-known specific names cannot be applied in a sufficiently comprehensive way to include the forms which the older authorities recognized under the names *A. serpentinus*, *A. jurensis*, and *A. Sowerbyi*, respectively?" But who are the older authorities in this matter? Surely they are those who in the first place imposed these names on certain definite species which they figured, and are we to perpetuate a mistake because since then certain authors and collectors have entirely mistaken the identity of the fossils so named? Mr. Haddow supposes, I fancy, that the species which the later authors had in view are merely varieties of what the older authors

had named, and that now there is "a tendency to confine a species within narrower limits than heretofore." I contend, however, that this is not the fact, but rather that we are in possession of an increased number of new forms and an increased amount of knowledge concerning their affinities and differences, and most certainly it is not the fact with regard to the species which he quotes. *Am. serpentinus* is not only not the same species, but so far as I can judge, not even the same genus as *Am. falcifer*. The large Ammonite figured as *jurensis* by Dr. Wright is not only most certainly not Zieten's species, but is even characteristic of the *Opalinum*-zone. The name *Ammonites jurensis* has been the cause of some singular mistakes. I believe that it is an open secret that when Dr. Wright first visited the Dorset Inferior Oolite, and saw the large *Lytoceras* which I have since named *Lyt. confusum*, he mistook it for *Am. jurensis*, and therefore classed the Inferior Oolite there as Lias, considering it to be on the same horizon as the Gloucestershire Cephalopoda-bed. Is not this an instance of the harm that can be done by extending the scope of a specific name? As to *Am. Sowerbyi*, it is none too easy to exactly determine what may be the adult form of the small specimen figured by Sowerby; but nevertheless my experience is that the majority of *Ammonites* labelled *Sowerbyi* in our public collections have but little to do with that species. When I first began collecting *Ammonites*, I found that all spinous falciform *Ammonites* of the Inferior Oolite were considered to be either *Am. Sowerbyi*, if with large coarse spines, or *Am. variabilis*, if compressed and with less conspicuous spines, and in fact the unfortunate meaning of the latter name was an excuse for placing any falciform *Ammonites* to that species that could not well be located elsewhere. This was the method of "general geologists," and the species they so named had nothing at all to do with d'Orbigny's *Am. variabilis* and but little with *Am. Sowerbyi*. What was the result? The ideas about the sequence of the Inferior Oolite beds and their correlation with those elsewhere were extremely indefinite, merely owing to a lax determination of the *Ammonites*.

Now I come to the trinomial system. Again I ask why should palæontological nomenclature differ from that of all other sciences? Are we likely to get other sciences to change their now well-established nomenclature from the binomial to the trinomial system, and if not, why should palæontology desire to be peculiar? The binomial system has been used by it hitherto, and it would cause as much inconvenience to change to the trinomial system as it will to continue the binomial and without, I think, the same advantage. Quenstedt has used a trinomial and even a quadrinomial nomenclature, but in a haphazard way, and when we come to such a name as his *Ammonites angulatus compressus gigas*, it seems to me that we have done with both elegance and utility. A modified trinomial system is practically in general use for varieties, and may well continue so, as *Ludwigia Murchisonæ*, var. *obtusa*. But supposing that the name of a well-known *Ammonite* is to be used instead of the new generic names, I would ask Mr. Haddow to kindly arrange the following species under a trinomial system, viz.:—

Ludwigia Murchisonæ.
,, ,, var. *obtusa.*
,, *cornu.*

or,

Lioceras elegans.
,, *opalinum.*
,, ,, var. *comptum.*

If he wrote *Ammonites Murchisonæ*, *Am. Murchisonæ obtusus*, and *Am. Murchisonæ cornu*, he would place *Am. cornu* in the same rank as the variety of *Murchisonæ*, which would not meet the facts of the case. If he leaves it *Am. cornu*, he does not show its relationship to *Am. Murchisonæ*, as I do by employing the word *Ludwigia*. Then would he write *Am. elegans*, *Am. elegans opalinus*, and *Ammonites elegans opalinus comptus?* If so, I fancy the system would be a more cumbrous obstacle to a beginner than the employment of many generic names; but if he wrote *Am. elegans comptus*, he would not state the facts of the case, which are, that *comptus* is a variety of *opalinus*, not of *elegans*. Then, what rule would be followed with regard to choosing the *Ammonite* which should be the leading one of the group? Surely that which selected the oldest known member, the one from which probably the others had descended, because an older species could hardly be placed subordinate to a younger one, which would happen by any other method. Therefore we choose *elegans* to be the dominant name, instead of using the new generic name *Lioceras*; but supposing we find a *Lioceras* older than *Am. elegans*, and such a thing is not unlikely to happen, then we must again change the dominant name throughout the group.

As regards the obstacles to beginners that these names present, I would remark that to them these changes do not present the same difficulty as they do to one who has been accustomed to an older system, and then has to unlearn and learn again. The beginner, never having learnt an old system, does not find the new one more unfamiliar than the old. Besides which, the use of these generic names is intended to point out and emphasize the differences in *Ammonites* which are now passed over owing to their being grouped in such large numbers.

Finally, with regard to the zones; we have not reached perfection, and must effect changes of name as our knowledge increases. I, too, can point out a zone that is in danger, viz. the well-known *Sauzei*-zone, because it seems most probable that the *Am. Sauzei*, d'Orbigny, was previously figured as *Am. contractus*, Sowerby; but d'Orbigny's figure being so much more easily recognized, his name came into more general use.

VIII.—Notes upon Ice Action in High Latitudes.

By Professor J. W. Spencer, M.A., Ph.D., F.G.S.

THESE notes are intended as an appendix to "Notes on the Erosive Power of Glaciers, as seen in Norway" (*vide* this Magazine, Decade III. 1887, Vol. IV. No. 4, p. 167).

1. The object of my visit to Norway and the Alps was to leave

closet-geology in America, in order to make personal observations of the phenomena associated with modern glaciers, —for comparison with those in the region of our Great Lakes, often attributed to land-ice. My conclusions—that simple land glaciers are not great eroding agents—are greatly strengthened, not merely by the observations of many other geologists, but particularly by those of various explorers in high latitudes—some of which are given here.

2. Herr Payer[1] states that the snow-line in Franz Josef Land descends to within 1000 feet of the sea (this is lower than is known anywhere else in the Arctic regions), and that numerous glaciers discharge great quantities of icebergs into the sea. He says:—"However diligently I looked for them, I never saw unmistakable traces of grinding and polish of rocks by glacial action."

3. Lieutenant Lockwood[2] found in Central Grinnell Land a thick ice-cap extending for a distance of 70–90 miles or more, faced by an ice-wall of a nearly uniform height of 125–200 feet, irrespective of topographical inequalities. It was quite free from rock-*débris*, except in a valley confined by mountainous walls, thousands of feet high. Along its foot there was almost an absence of morainic ridges, and even where present these deposits were unimportant fragments. The general absence of rocks and dirt in the Arctic glaciers is commented on by General Greely, who observed them only in two or three glaciers. The glaciation about Lake Hazen was not recent. The snow-line in this high latitude of Central Grinnell Land is 3800 feet above the sea.

4. In Spitzbergen, with a lower snow-line, Baron Nordenskjöld[3] found striated rock-surfaces only below 1000 feet. The same holds good with regard to Labrador, where mountains rise 6000 feet, whilst the glaciation has not been observed above 1000–1600 feet (Dr. R. Bell).[4]

5. In the Antarctic regions, the officers of the "Challenger"[5] remarked the absence of *débris* in the icebergs seen; although Ross in his Antarctic voyage examined volcanic rocks upon some of them. These volcanic blocks are supposed to have come from valleys in the mountains.

6. Indeed, outside the valleys, explorers in high latitudes have not found the tools for great erosion in the margins of the ice-caps visited. The continental area of North America presents much lower and less abrupt prominences than the reliefs of Greenland, Grinnell Land, Spitzbergen, or Franz Josef Land. Overhanging mountains seem to be necessary to furnish tools to land glaciers, by which alone any abrasion can be accomplished, and these conditions belong only to the valleys of great mountain ranges.

7. However, there is one condition, under which glaciers when shod with graving tools ought to be great eroders,—namely, when

[1] "New Lands within the Arctic Circle," 1872–74, Payer.
[2] "Three Years of Arctic Service," 1881–84, Greely.
[3] See Geological Magazine, 1876.
[4] Hudson's Bay Expedition of 1884.
[5] Notes by a Naturalist of the "Challenger," 1879, Moseley.

the motion is much more rapid than the flow of land-ice, which is three feet a day or less, and corresponds to the experimental movement—shown by Herr Pfaff,—under which conditions, as seen in Norway, included stones commonly adhere by friction to the subjacent rocks, and cause the lower surfaces of the ice to be grooved. Extraordinarily rapid movement has been seen at Jacobshavn glacier in Greenland, where Prof. A. Helland[1] found that the velocity reached 40–60 feet a day. In Alaska, Lieut. Schwatka[2] and Prof. G. F. Wright[3] observed a movement of 40–70 feet a day. In these cases the glaciers are moving into the sea, and a new element of partial flotation or sliding, which does not belong to the glaciers on land, is here introduced. The great velocity of these glaciers is far beyond any known ability of ice to flow as a plastic body. Consequently one is led to conclude that under partial flotation stones may be held firmly as graving tools by glaciers.

8. The appeal to the former magnitude of ice-masses as accomplishing different results from those seen at present seems to be begging the question, for the action under a greater thickness would differ from that under a lesser, in amount rather than in kind, for increased pressure upon the ice—raising the temperature—increases its plasticity, as the general mass is not below freezing-point. Consequently it seems improbable that stones should be held firmly under the changed condition, for in addition to the increased plasticity, the friction between the stones in the ice, and the rock, is also increased by the greater weight of ice.

9. Over the vast area of action, the work of floating or sea-ice in some form, is enormous.

On the northern side of Hudson Straits Dr. John Rae,[4] who had very extensive Arctic experiences, found that snow, drifting over precipices into the sea, resulted in the formation of bergs 100 feet thick (filled with loose rock-*débris* of the coast), having the form of the shore where they were produced. Most of the bergs break loose and drift away to melt or become stranded elsewhere.

10. Greely describes the great momentum with which floebergs come together, and by their meeting, the ice is crushed and forced up into ridges 50 to 60 feet high.

11. One cannot carefully read the results of the last British Arctic Expedition of 1875-76, under Sir George Nares, without being impressed with the erosive power of drifting ice. Floebergs are pushed upon a shelving sea-bottom, until the ice has risen 20—60 feet, after their first stranding, in perhaps only 48—72 feet of water, although of gigantic weight. As the grounded floebergs are forced up the shelving sea-bottom, ridges of earth and stones are pushed up in front of them. Floebergs which have toppled over, thus showing their original bottoms, and also the pushed-up coast-ice, are found to be grooved and to contain angular stones with their exposed

[1] See Q.J.G.S. 1877.
[2] *N.Y. Times* Alaska Expedition, 1886.
[3] The Muir Glacier, Amer. Journ. Sci. 1887.
[4] Canadian Journ. Toronto, 1859.

surfaces scratched and polished. As the movement is greater than the possible velocity of glaciers, it is only natural to expect great erosive effects from stones held as graving tools, or wrenched out owing to the brittleness of the ice, under such great stress, or from loose materials roughly thrust forward by the pack.

12. These observations and those of Prof. Milne[1] in Newfoundland, and others upon the action of coast-ice, all confirm the correctness of the verdict given by many geologists, especially in Europe, who have had the opportunity of studying living glaciers, viz. that the potency of land-glaciers as great *eroding* geological agents is not proven, if indeed they operate at all in such a manner.

IX.—Tertiary Outliers on the North Downs.

By the Rev. A. Irving, B.Sc. (Lond.), B.A., F.G.S.

In "Nature," August 26, 1886, vol. xxxiv. p. 387, I ventured to draw a distinction between the outliers of unfossiliferous Tertiary sands found at high altitudes on the North Downs and the deposits containing casts of fossils of Pliocene age which are found in hollows in the Chalk at Lenham. Last summer I visited and examined, I believe, all the more important outliers of the former series, Mr. J. Hutchins French, F.G.S., having kindly conducted me to those at Headley and Chipstead; those at Netley were visited with other members of the Geologists' Association under the direction of the same gentleman. The conclusion at which I have arrived from the lithological evidence (and there seems to be no other available) is, that these sands are more probably of Bagshot age than of any other.[2]

There is a vast amount of reconstructed clay material capping these hills over many square miles, which, in colour and other characters, points to its original deposition as part of the Reading Beds, and in these unrolled Chalk flints are generally sparsely distributed. There are also a good many outliers of those beds mapped by the Survey on the higher parts of the North Downs.[3] But there appear to be no traces of London Clay or of the Middle Bagshot clays.

Of the unfossiliferous sands referred to, those exposed in the sand-pit in Chipstead Wood, and those seen in the pit on Netley Heath (where only one section occurs of undoubted Tertiary sands *in situ*, clearly differentiated from the overlying "run-of-the-hill" of later

[1] See Geological Magazine, Dec. II. Vol. III. No. 7, p. 303, 1876.

[2] "Nature," Oct. 16, 1887, vol. xxxvi. p. 531.

[3] Surely these are the patches of "clay-with-flints" (*Argile à silex*) of W. Whitaker and the French and Belgian geologists.—H. W.—The clays referred to are quite distinguishable from the "clay-with-flints" of Mr. Whitaker and the Survey, if by that term is understood the insoluble residue frequently found on the surface of the Chalk, the calcareous constituents of the original rock having been dissolved away by carbonated atmospheric waters; a kind of deposit known to the French geologists as "argile à silex" or "terrain superficiel de la craie" (Memoir *Les Causes Actuelles en Géologie*, p. 306).—A. I.

date) are the *exact counterpart in every way of the Upper Bagshot Sands*, as these are seen in the interior of the district; *e.g.* about Sandhurst, in the Fox Hills, and at Aldershot. Of those at Headley I should speak with more reserve as to their being *Upper* Bagshot, although I saw no good grounds for denying that they might represent the more marginal facies of the beds of that group. There is rather more distinctness of bedding than usual, and the sands are rather less loamy, and more marked by colour-bands, as the result of subsequent infiltration. But this can be observed even in the highest beds of the Fox Hills in places, and elsewhere in the district.

Associated with these sands on the Chalk hills at Headley, and in the *débris* of the hill-slope, well-rounded flint pebbles are met with in great numbers; at Headley they constitute a large proportion of the drift-gravel, which overlies the sands. These pebbles are so different from those which occur *in the clays* on the Downs, and so closely resemble the bluish Bagshot pebbles of Bearwood, Easthampstead, St. Anne's Hill, Chertsey, Aldershot, etc., that it seems impossible to deny that they may belong to the same formation. Sarsens also are not infrequently met with.

So far as the evidence goes, we seem (though it is not very strong) to have better grounds for assigning these outlying sands to the Bagshot (and perhaps to the Upper Bagshot), than any which has yet been brought forward for assigning them on the one hand to the Reading Beds, and on the other to the Pliocene.[1]

Assuming that they are of Bagshot age, and taking their present altitudes (550 to 600 feet above O.D.) into account, we arrive at the interesting and important result, that this represents approximately the extent of the post-Eocene elevation of the North Downs above the sea; and the differences between these and the present altitudes of the same horizons in the interior of the Bagshot area (if they could be precisely identified) would represent the extent of accentuation which the Wealden axis has undergone since the Eocene period.

The extensive prevalence of the Reading Beds to the south points to a later date for the elevation of the Wealden axis than that marked by those beds; while the presence of the pebbles in great force seems to indicate that the Chalk over the Wealden area was subjected to the abrading action of the sea to a large extent before the Eocene period[2] came to an end (as is well known); and to such an extent was this carried on, that even the Lower Greensand was exposed to the action of denuding agencies, and furnished a great part of the materials of the Upper Bagshot, in which scattered glauconitic grains occur locally.

[1] See Mem. Geol. Survey, vol. iv.
[2] Exclusive of the Oligocene.

X.—On the Occurrence of a Glaucophane-bearing Rock in Anglesey.

By Prof. J. F. Blake, M.A., F.G.S.

THE occurrence of glaucophane has not, I believe, been previously noted in Great Britain, and as it is a mineral of some interest, my friend Mr. Teall has suggested that a separate notice of it should be given. It would otherwise be naturally described in the Report on the Microscopic Structure of Anglesey Rocks to be presented to the British Association at their forthcoming meeting.

The rock which contains the mineral in question has already, in a certain sense, been described by Prof. Bonney in the Quarterly Journal of the Geological Society, vol. xxxv. p. 308, in the following words :—

"XII. Quarry near Anglesey Monument.

"A foliated dense felted mass of a dull greenish, rather decidedly dichroic mineral (probably a species of chlorite), and of small greenish yellow epidote crystals, with a few angular fragments of quartz (?), and two or three scales of mica (? paragonite)."

This description shows that the specimen which afforded it was one in which the glaucophane had gone over into chlorite, which it very frequently is found to do. In fact, there are many exposures of rock around the Anglesey Monument and to the south of it, which obviously, from their mode of occurrence and their connection with each other, all belong to the same mass, and their minute structure is of the same type; but in most the colouring mineral is a chlorite, and only in some of the freshest exposures, or in particular spots, is the original glaucophane seen. Elsewhere, by identity of structure and mode of recurrence, we may still recognize portions of the same mass in which the mineral is ordinary hornblende.

These rocks have been hitherto taken to be identical with the dark schists of the district in which the prevailing mineral is chlorite, and only recently has Dr. Callaway, at the British Association, come round to consider some of them igneous.

The beautiful blue tint of the glaucophane gives a very rich aspect to the rock under the microscope, by which the long crystals of this mineral are seen enwrapping and felting over the short crystals of epidote. The rock is so very foliated, in such excessively fine lines, and these are so beautifully contorted, that I had much difficulty at first in recognizing it as igneous; and since, according to my experience, hornblende in Anglesey is limited to igneous rocks, I had great difficulty in believing this blue mineral could really be glaucophane, which is only a variety of hornblende. However, I showed it to M. Renard at the meeting of the British Association, and he thought it would probably be glaucophane, and I therefore had a transverse section cut, and that set the matter at rest.

Prof. Rosenbusch in his "Mikroskopische Physiographie," p. 471, gives the following as the characters of Glaucophane :—

"It occurs always in prismatic crystals, bounded by the faces of ∞P (100) and occasionally with $\infty P \grave{\infty}$ (010) or $\infty P \bar{\infty}$ (100), but without terminal faces. The usual cleavage is parallel to the prism with the amphibole angle (124° 25′—124° 44′), and the blue colour in reflected light makes it easily recognizable. Besides the cleavage, there is a very characteristic splitting, in which it particularly resembles actinolite. Glaucophane in the amphibole group corresponds pretty nearly with jadeite amongst the pyroxenes. The angle of extinction as measured on the plane of symmetry is very small, 4°—6°. The pleochroism is particularly clear and fine —c = sky-blue to ultramarine, rarely blue-green; b = reddish violet to bluish violet; a = nearly colourless to golden green. S.G. = 3·0—3·1. Glaucophane appears to be entirely confined to the crystalline schists and phyllites. The paragenesis of glaucophane is the same as that of actinolite and common hornblende, it is associated with diallage, omphacite, garnet, epidote, mica, and rutile."

The characters are perfectly possessed by the mineral in the Anglesey rock. It occurs in narrow elongated prisms, which are generally twisted round the epidote grains, and run into each other; but in clear spaces, filled with quartz, some isolated narrow crystals appear, at least 8 times as long as broad, and appearing to die out like wedges at either end; in other words, they have no terminal faces. These prisms seen in polarized light without the analyzer are blue when their long axes are parallel to the principal, *i.e.* the short axis of the Nicol, and nearly colourless when perpendicular. In ordinary light these of course produce a lighter tint of blue. As the mineral passes over into chlorite, this blue changes into green, as it may be seen to do in a single slide. As the long axis of a hornblende or glaucophane crystal lies near to c, this blue is the characteristic one, and the colour seen in the perpendicular direction is a combination of the other two. When the prism is cut perpendicularly to its length, a rhombic section is seen. If the longer diameter of this rhombus, which corresponds to b, is placed parallel to the principal plane of the Nicol, the colour is dirty violet; and if the short one corresponding to a is so placed, the crystal becomes colourless. With regard to the angles of this rhombus, its very small size, ·004 in., in longer diagonal, and the uncertainty of the direction in which it may be cut, renders the observation not very close. But the acute angle in three distinct trials I estimated at 55°, 56°, and 55° 20′, giving a mean of 55° 27′, or for the obtuse angle 124° 33′, which is within the limits given by Rosenbusch. These are the usual forms, but in one case is seen a rhomboid whose obtuse angle was estimated at 125°, and which would therefore probably be obliquely cut, as shown also by one pair of sides being lengthened. and in this the acute angles are cut off by narrow planes making equal angles with the two sides. While therefore the rhombuses have their edges formed by 110, this shows the trace of the 010. I have not observed any crystal with the trace of 100. The lines of cleavage are parallel to the faces of the rhombus. With regard to the

extinctions, when the long prisms are seen, they are either so matted together that no direction of edge can be ascertained, or they float in quartz, and no good extinction can be observed; but the darkest phase makes a large angle of about 15°, with the length of the prism.

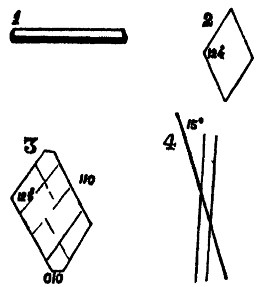


Fig. 1.—Prism of glaucophane seen perpendicular to the longer axis *c*.
Fig. 2.—End of the rhombic prism showing obtuse angle of 124°.
Fig. 3.—Prism (110) modified by planes of the pinacoid (010).
Fig. 4.—Showing plane of extinction making angle of 15° with the long axis of the prism.

These observations leave no doubt that the mineral is glaucophane. Its associates are epidote, rutile (?), quartz, felspar (?), and calcite. The epidote is very abundant in small highly polarizing grains, so that the rock is actually a glaucophane-epidote rock. As epidote is chiefly characterized by its lime, and glaucophane by its soda, we may suppose that the rock is essentially a diorite, in which there would normally be a soda-lime felspar and a hornblende; but that either at its formation under peculiar circumstances, or by later alterations, the soda combined with the hornblendic ingredients to produce the variety glaucophane, while the lime caused epidote to be substituted for felspar. The rock is singularly free from garnets, though one patch may be this mineral. There are also a number of small prismatic-looking specks of a rich brown colour, which are sometimes kneed, and which may possibly be rutile. These are the minerals essential to the rock; the others have been produced during the squeezings and stretchings to which it has been subject. Their interest lies in the fact that some of the crystals of glaucophane float freely in the clear crystalline substance, and the untorn substance does not look as if it could supply such crystals by tearing. It is thus suggested that the glaucophane *as such* may have been produced subsequently to the infiltration of the quartz.

I have to thank my friend Mr. Teall for suggestions relating to this matter, and for taking the trouble to verify the determination of the mineral.

NOTICES OF MEMOIRS.

I.—Glaciation of Salzach District.

Die Vergletscherung des Salzachgebietes nebst Beobachtungen über die Eiszeit in der Schweiz. von Dr. Eduard Brückner. Geographische Abhandlungen; herausgegeben von Dr. Albrecht Penck. Bd. 1. (Vienna, Hölder, 1887.)

Dr. BRÜCKNER'S paper on the glaciation of the Salzach district furnishes us with another chapter in the history of the Glacial period on the northern slopes of the Alps. Whilst previous writers, such as Al. Favre and Falsan, have traced out the development of the Rhone glacier of the ice period, and Penck has worked at the glacial deposits between the Lake of Constance and the Chiem Lake, the present author has chosen the district of the Salzach, further to the eastward, as the field of his observations, and has in this memoir accumulated a great amount of detailed evidence on the extent of the glaciation, its effects on the configuration of the surface and its recurrence at distinct intervals. The results obtained agree with and confirm those of the authors above mentioned in the more westerly districts of the Alps.

One very noticeable fact is the decrease in the intensity of the glaciation in passing from the west towards the east. This is well shown by the author in a table in which a comparison is made between the level of the upper surface and the thickness of the more important Alpine glaciers at their points of issue from the mountains, together with the respective distances and the levels to which they extended from the foot of the mountains and the width of their outer morainic areas. Thus, for example, the upper surface of the ancient Rhone-glacier at the position indicated was 1500 mètres and its thickness 1300 mètres; it reached 170 kilom. from the mountains, and descended to a level of 300 m. The old Salzach glacier, on the other hand, was only 650 m. in thickness, and its upper surface 1050 m., whilst it only reached 32 kilom. from the mountains, and not lower than 500 m. The height of the snow-line in the Salzach district during the Glacial period is estimated at 1200 m.

The author points out the very distinctive character of the two zones of ancient moraines; an outer, distinct petrographically as well as by its having a covering of Loess or of a fine clay of a similar character, and an inner moraine which has a well-marked terminal wall, and is without a layer of Loess. The author has ascertained the extension of the inner moraine over the Loess as well as over the outer moraine, thus indicating its interglacial age, and he has further discovered no fewer than seven profiles in which the two moraines were clearly separated from each other, either by the Loess, or by important beds of gravel and conglomerate, thus showing an interglacial interval between their deposition. The high terrace gravels which occur beneath the outer moraine, and the lower terrace gravels deposited in advance of the inner second moraine, are well developed in the Salzach district, and the author further describes

a third series of widely-distributed gravels, which are believed to indicate a more extensive and an older advance of the glaciers.

The character and origin of the lakes not only of the Salzach district, but of the Linth and those of the Neuenburg group, are fully treated, and a special chapter is devoted to the Glacial deposits of the Lake of Geneva.

The text is accompanied by several figures and tables, as well as by three elaborate coloured maps of the district described.

II.—The Matrix of the Diamond. By Prof. Carvill Lewis.

(Abstract of a Paper read at the Manchester Meeting of the British Association, September, 1887.)

A MICROSCOPICAL study of the remarkable porphyritic peridotite which contains the diamonds in South Africa demonstrates several interesting and peculiar features.

The *olivine*, forming much the most abundant constituent, is in porphyritic crystals, sometimes well bounded by crystal faces, at other times rounded and with corrosive cavities, such as occur in it in basaltic rocks. It rarely encloses rounded grains of glassy bronzite, as has been observed in meteorites. The olivine alters either into serpentine in the ordinary way, or into an aggregate of acicular tremolite crystals, the so-called '*pilit*,' or becomes surrounded by a zone of indigo blue bastite—a new variety of that substance. The olivine is distinguished by an unusually good cleavage in two directions.

Bronzite, chrome diallage, and *smaragdite* occur in fine green plates, closely resembling one another. The bronzite is often surrounded by a remarkable zone, with a centric pegmatitic, or chondritic structure, such as occurs in certain meteorites. This zone is mainly composed of wormlike olivine grains, but a mineral having the optical characters of cyanite also occurs in this zone.

Biotite, a characteristic constituent, occurs in conspicuous plates, often twinned, generally rounded, and distinguished by its weak pleochroism, a character peculiar to the biotite of ultra-basic eruptive rocks. It alters by decomposition into the so-called *Vaalite*.

Perowskite occurs in very numerous but small crystals, which optically appear to be compound rhombic twins.

Pyrope is abundant in rounded red grains. Titanic iron, chromic iron, and some fifteen other minerals were also found. Rutile is formed as a secondary mineral through the alteration of olivine into serpentine, being a genesis of rutile not heretofore observed.

The *chemical composition* shows this to be one of the most basic rocks known, and is a composition which by calculation would belong to a rock composed of equal parts of olivine and serpentine, impregnated by calcite.

The *structure* is at the same time porphyritic and brecciated, being one characteristic of a volcanic rock which after becoming hard had been subjected to mechanical movements. It is a volcanic breccia, but not an ash or tuff, the peculiar structure being apparently due

to successive paroxysmal eruptions. A similar structure is known in *meteorites*, with which bodies this rock has several analogies. A large amount of the adjoining bituminous shale is enclosed, and has been more or less baked and altered. The occurrence of minute tourmalines is evidence of fumarole action.

The microscopical examination supports the geological data in testifying to the igneous and eruptive character of the peridotite, which lies in the neck or vent of an old volcano.

While belonging to the family of peridotites, this rock is quite distinct in structure and composition from any member of that group heretofore named. It is more basic than the picrite porphyrites, and is not holocrystalline like dunite or saxonite. It is clearly a new rock-type, worthy of a distinctive name. The name *Kimberlite*, from the famous locality where it was first observed, is therefore proposed.

Kimberlite probably occurs in several places in Europe, certain garnetiferous serpentines belonging here. It is already known at two places in the United States: at Elliott County, Kentucky, and at Syracuse, New York; at both of which places it is eruptive and Post-Carboniferous, similar in structure and composition to the Kimberley rock.

At the diamond localities in other parts of the world diamonds are found either in diluvial gravels or in conglomerates of secondary origin, and the original matrix is difficult to discover. Thus, in India and Brazil the diamonds lie in conglomerate with other pebbles, and their matrix has not been discovered. Recent observations in Brazil have proved that it is a mistake to suppose that diamonds occur in itacolumite, specimens supposed to show this association being artificially manufactured. But at other diamond localities, where the geology of the region is better known than in India or Brazil, the matrix of the diamond may be inferred with some degree of certainty. Thus, in Borneo, diamonds and platinum occur only in those rivers which drain a serpentine district, and on Tanah Laut they also lie on serpentine. In New South Wales, near each locality where diamonds occur, serpentine also occurs, and is sometimes in contact with Carboniferous shales. Platinum, also derived from eruptive serpentine, occurs here with the diamonds. In the Urals, diamonds have been reported from four widely separated localities, and at each of these, as shown on Murchison's map, serpentine occurs. At one of the localities the serpentine has been shown to be an altered peridotite. A diamond has been found in Bohemia in a sand containing pyropes, and these pyropes are now known to have been derived from a serpentine altered from a peridotite. In North Carolina a number of diamonds and some platinum have been found in river sands, and that State is distinguished from all others in eastern America by its great beds of peridotite and its abundant serpentine. Finally, in northern California, where diamonds occur plentifully and are associated with platinum, there are great outbursts of Post-Carboniferous eruptive serpentine, the serpentine being more abundant than elsewhere in North America. At all the localities mentioned chromic and

titanic iron ore occur in the diamond-bearing sand, and both of these minerals are characteristic constituents of serpentine.

All the facts thus far collected indicate *serpentine*, in the form of a decomposed eruptive peridotite, as the original matrix of the diamond.

III.—Permian Fossils from Spitzbergen.

Anmärkningar om Permfossil från Spetsbergen, af Bernhard Lundgren. Bihang till K. Svenska Vet. Akad. Handlingar. Bd. 13 (1887), Afd. iv. No. 1, pp. 3—26, t. 1.

THE fossils from Spitzbergen which by de Koninck[1] and Geinitz were accepted as proving the Permian character of the beds in which they occurred, were shown subsequently by Lindström to be associated with species which, in other localities, are distinctly characteristic of the true Carboniferous Limestone, and the Spitzbergen strata, in which this intermingling of Carboniferous and Permian fossils takes place, have therefore been termed the Permo-carbon series. In the Swedish expedition to this island in 1882, Nathorst and De Geer discovered in Belsund and Tcefjord a series of rocks, principally shales and sandstones, reaching a thickness of about 300 mètres, which rests upon the thick mass of cherty and siliceous rocks of the Permo-carbon series, and are overlaid by rocks with Trias fossils. A scanty fauna, entirely marine, was found in this sandstone and shale series, and is described in this paper by Prof. Lundgren. It consists principally of small Brachiopods and Lamellibranchs with a single Coral, *Stenopora columnaris*, Schlot. Some of these forms are identical with, and others are closely allied to, those in the Permian series of England, Germany, Petschora-land, and the North-west of North America. In these Spitzbergen rocks all the fossils are distinctly of a Permian type, and the Carboniferous Limestone forms have quite disappeared, thus showing a gradual extinction of these latter before the deposition of this series, which may justly be regarded as Permian. Prof. Lundgren figures the new forms, which are of a dwarfed character. G. J. H.

IV.—Preliminary Observations on the Geology of Wicklow and Wexford. By Professor Sollas, LL.D., F.G.S.

OF rocks older than the Cambrian examples probably occur in the Carnsore district, but most of the presumed Archæan rocks are to be explained as crushed igneous dykes and flows. The Cambrian are certainly unconformably succeeded by the Ordovician.

The main granite of the district is a truly intrusive rock; but at its junction with the Ordovician which it penetrates, it possesses the characters of a true gneiss, the schistosity of which corresponds in direction with that of the adjoining schists, having resulted from earth-movements which took place after the Ordovician and before the Lower Carboniferous period.

[1] Bull. de l'Acad. Royale de Belgique, ser. 1, vols. 13, 16.

REVIEWS.

I.—On the Structure and Classification of the Mesozoic Mammalia. By Dr. Henry F. Osborn. Proc. Acad. Nat. Sci. Philadelphia, June 21st, 1887.

THIS paper is an outline of Professor Osborn's observations "upon the structure of the British Mesozoic Mammals and a Classification of the Mesozoic Mammals in general, in view of their relationship to each other and to recent orders." The author, who is well known by his numerous palæontological and morphological researches conducted in the Princeton College laboratories, has had the opportunity of examining the type-specimens of all the Mesozoic Mammals hitherto described, except four. The results of so extended a study are thus of unusual interest and significance. After some preliminary remarks, a series of notes are offered upon the English fossils, described by Owen; and the succeeding larger section of the paper is occupied with a general scheme of classification.

Referring first to the Stonesfield Slate jaws, Dr. Osborn remarks that three distinct genera are commonly included under the name *Amphitherium*. The molar of *Amphitherium* proper (type *A. Prevostii*) is bicuspidate, with a low posterior heel; that of *Amphitylus*, gen. nov., has three blunt cusps and an internal cingulum; while that of *Amphilestes*, Owen (type *A. Broderipii*), has three prominent cusps, and a pronounced cingulum, encircling the crown. The lower dental formula of *Phascolotherium* is given as i. 4, c. 1, pm. 0, m. 7.

Triconodon is the first Purbeck genus remarked upon. Dr. Osborn points out that in this primitive form, the fourth premolar early replaces a molariform milk-tooth, and the fourth true molar is very late in rising, thus agreeing precisely with the mode of succession determined by Professor Flower in certain existing Marsupials. *Triacanthodon* consequently becomes a synonym of *Triconodon*. *Phascolestes* is considered to be quite distinct from *Peralestes*, and *Leptocladus* from *Stylodon*. *Spalacotherium* has the lower dental formula, i. ? 2, c. 1, pm. 4, m. 6. The maxilla referred by Owen to *Stylodon* must be removed to a distinct genus, *Kurtodon*,[1] characterized by the compact arrangement and peculiar wearing pattern of the crowns, and a new enlarged figure is given in illustration. The maxillary formula of *Bolodon* is found to be i. ? 2, c. 0, pm. 3, m. 4, and the characters of these teeth are also shown in a woodcut.

The following is a synopsis of the proposed classification :—

I. Multituberculata.—One incisor greatly developed at the expense of the others and of the canine; diastema, varying in width, in front of the premolars; molars characterized by two or more antero-posterior rows of tubercles separated by longitudinal valleys or grooves.

Fam. 1. Plagiaulacidæ. *Ctenacodon, Plagiaulax, Ptilodus*. (Also the Tertiary *Neoplagiaulax*.)
Fam. 2. Bolodontidæ. *Bolodon, Allodon*.
Fam. 3. Tritylodontidæ. *Tritylodon*.

[1] In the original paper, the preoccupied term *Athrodon* is employed. This is replaced by *Kurtodon* in the "Amer. Nat.," Nov. 1887, p. 1020.

" II. SECOND GROUP.—Incisors numerous and sub-equal in size; canines large; usually no diastema; premolar-molar series usually in excess of the typical number; molars cusped rather than tubercular.

A. *Jurassic Mammals.*

(i.) *Carnivorous.* Canines large, erect,; molars with strong internal cingulum; premolars with basal cusps; condyle of mandible low, and coronoid process broad.

Fam. 1. Triconodontidæ. *Triconodon* (= *Triacanthodon* + *Priacodon*), *Amphilestes.* (?) *Amphitylus* and *Amphitherium.*
Fam. 2. Phascolotheridæ. *Tinodon*, *Phascolotherium.*
Fam. 3. Spalacotheridæ. *Menacodon*, *Spalacotherium.*

(ii.) *Omnivorous.* Lower canines large, erect; molars with more or less prominent internal row of low cusps; condyle usually on or below the molar level.

Fam. 4. Peralestidæ. *Peralestes*, *Peraspalax.*
Fam. 5. Paurodontidæ. *Paurodon.*
Fam. 6. Diplocynodontidæ. *Docodon*, *Diplocynodon*, *Enneodon*, (?) *Peramus.*

(iii.) *Insectivorous.* Incisors procumbent and spatulate; canines small; molars without cingulum; condyle high, coronoid process slender.

Fam. 7. Amblotheridæ. *Achyrodon*, *Amblotherium.*
Fam. 8. Stylodontidæ. *Stylodon* (= *Stylacodon*), *Aesthenodon*, *Laodon*, *Dryolestes*, *Phascolestes.*

(iv.) *Herbivorous.* Molars without cusps.

Fam. 9. Kurtodontidæ. *Kurtodon.*

B. *Triassic Mammals* (*Protodonta*, ? new order).

Fam. 10. Dromatheridæ. *Dromatherium*, *Microconodon.*

It is now generally admitted that many of the genera embraced in Cope's MULTITUBERCULATA were Marsupials, and Dr. Osborn regards this group as most probably a suborder of the Marsupialia. The second group, however, is of a very different character, and Prof. Marsh has raised its Jurassic members to the rank of a new order [see GEOL. MAG. July, 1887]. This arrangement presents some difficulties, and Dr. Osborn's concluding remarks are devoted to these as follows:—"It is impossible to find a single common character[1] or set of characters for these genera which is of ordinal value. On the other hand, there are many grounds for placing the *Triconodontidæ*, *Peralestidæ*, and *Kurtodontidæ*, and their affiliated families, in or near the ancestral lines of the modern *Dasyuridæ* and *Phascolomyidæ* respectively, while the *Stylodontidæ* are similarly related to the [Placental] *Chrysochloridæ*. These grounds may be partially stated. (1) *Triconodon* has one more premolar, but otherwise resembles *Thylacinus* both in the structure of the mandible and in the form and succession of the teeth. (2) *Peraspalax*, although much more imperfectly known, is allied to *Dasyurus* in its molar structure. (3) *Kurtodon*, although differing from *Phascolomys* in the possession of a large canine, shows a marked resemblance to this genus in the molar structure. . . . In the *Amblotheridæ* and *Stylodontidæ* we probably have a line of Insectivora. *Dryolestes* has

[1] The mylohyoid groove is universally present, but is also found in *Myrmecobius*.

a molar pattern which is not observed in any Marsupial, but is seen in *Chrysochloris* among the Insectivora. Since, however, it is common for Marsupials to mimic the dentition of other orders, this relationship must be held with some reserve." A. S. W.

II.—Department of Mines, New South Wales.

(1.) Annual Report of the Department of Mines, New South Wales, for year 1886. Sydney, 1887.

(2.) Geology of the Vegetable Creek Tin-Mining Field, New England District, New South Wales. By T. W. Edgeworth David, B.A., F.G.S. Department of Mines, Sydney, 1887.

The annual report for the most part consists of details of the nature and amount of work carried on in the various mines of gold, silver, tin, copper, coal, and other minerals in different parts of the country, as well as of the character and prospects of the newly discovered mineral districts by the geological surveyors, under the direction of Mr. C. S. Wilkinson, F.G.S., the head of the Survey. Of more than local interest is a report on New South Wales Diamonds, by Thos. Davies, F.G.S., and Robt. Etheridge, jun., in which, amongst other things, they point out that the diamonds from this country, in their physical characters are more nearly allied to those of Brazil than of any other country: that they are of greater hardness, which is a disadvantage as regards the cost of cutting, but on the other hand they are extra brilliant. The diamonds occur in drift which may be loose and coarse, and in places passes into a compact conglomerate. This drift is due to fluviatile action at different geological periods. Thus there is no resemblance to the diamantiferous rock of the celebrated Kimberley mines of South Africa. Mention is made of the discovery of specimens of *Mastodonsaurus* in the Hawkesbury series at Cockatoo Island, and of a new species of univalve shell which is described by Mr. Robert Etheridge as *Tremanotus maideni*, thus belonging to a genus hitherto only known from the Silurian rocks of North America and Europe. The form described is from the Hawkesbury sandstone, but there is a possibility that it may have been contained in a boulder of an older date.

The volume on the Vegetable-Creek Tin-mining Fields, by Mr. Edgeworth David, gives a detailed account of the geological structure of the district accompanied by maps and sections. The tin-stone is met with principally in gravels, some of which are of Post-Tertiary age, whilst others are beneath massive beds of basalt and other eruptive rocks. The source of the tin-stone has been traced to veins in granite which occurs plentifully in the district. G. J. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—January 25, 1888.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "On *Ailurus anglicus*, a new Carnivore from the Red Crag." By Prof. W. Boyd Dawkins, M.A., F.R.S., F.G.S.

The specimen described is a small fragment of the right lower

jaw with the last three molar teeth in position, and belongs to the Crag collection of the Yorkshire Philosophical Society. It differs in a marked degree from all fossil European Carnivores, and presents no important points of difference when compared with a series of jaws of recent *Ailurus*. The author gave a description of the fossil and comparison of it with *Ailurus fulgens*, and also a table giving the comparative measurements of the teeth and jaws of the fossil and of recent *Ailuri*. The species from the Crag was a more powerful animal than any recent *Ailuri* in the British Museum. The paper concluded with a notice of the range of *Ailurus* in space and time.

2. "A Contribution to the Geology and Physical Geography of the Cape Colony." By Prof. A. H. Green, M.A., F.R.S., F.G.S.

The account given in this paper of the geology of Cape Colony was founded on observations made during a visit to the country of four months' duration for the purpose of reporting upon the coal. A considerable portion of the colony was traversed by the author, and, owing to the clear atmosphere and the barrenness of the surface, the rocks were unusually well seen. Much, too, had been ascertained by previous observers.

The grouping of the South-African rocks adopted was the following:—

9. Stormberg Beds { Volcanic Beds, 9 *d*. Cave Sandstone, 9 *c*. Red Beds, 9 *b*. Molteno Beds, 9 *a*.
8. Karoo Beds.
7. Kimberley Shales.

Great Unconformity.

6. Ecca Beds.
5. Dwyka Conglomerate.

Unconformity.

4. Quartzite of the Zuurbergen, Zwartebergen, and Wittebergen.
3. Bokkeveldt Beds.
2. Table-Mountain Sandstone.

Great Unconformity.

1. Slates and intrusive Granite of the neighbourhood of Cape Town (Malmesbury Beds).

Of the four lowest subdivisions very little was seen. The Bokkeveldt Beds had yielded fossils referred to Devonian. The detailed descriptions commenced with the Dwyka Conglomerate, which was coarse, containing both rolled and angular fragments, the matrix, which was ill bedded, resembling granitic detritus. Some of the boulders suggested doubtfully the action of ice. The Ecca Beds consisted of hardened sandy clays, without lamination, and often weathering in spheroids, and resembling decomposed basalt or dolerite. These beds in the Ecca Pass, north-east of Grahamstown, were nearly 5000 feet thick.

The Kimberley Shales were mainly grey and dark sandy shales, with a few thin layers of argillaceous limestone. At their base a conglomerate, resembling the Dwyka Conglomerate, was sometimes found. The Karoo Beds were red and purple shales, with buff or reddish sandstone containing much decomposed felspar.

The Molteno Beds, also sandstones and shales, usually grey- and

dark-coloured, associated with grits and conglomerate, contained the only useful coals of the colony. These coals were peculiarly laminated and contained much ash; the seams were destitute of sandstones and often eroded on the upper surface. These characters might indicate subaqueous origin. Owing to the irregularity of the seams, the views generally formed of the coal-resources of the colony may be exaggerated. The upper subdivisions of the Stormberg Beds, the Red Beds, shales and sandstones of a red colour, the Cave Sandstone, a massive, fine-grained bed 150 feet thick, weathering white, and the bedded amygdaloidal lava-flows and tuffs that cap the whole, were but briefly noticed, as but few opportunities had offered for examining them.

Some petrological details were given of the contemporaneous and intrusive traps, all appearing to contain the same constituents as the overlying subaerial traps, and doubtless belonging to the same series of volcanic outbursts.

The author proceeded to review the lie of the rocks and physical structure of the country, distinguishing between the area of older rocks near the coast and the later deposits commencing with the Dwyka Conglomerate of the interior. There was apparently unconformity at the base of this conglomerate; it and the overlying Ecca Beds were thrown into folds and occupied the Karoo Plains, whilst the ranges to the northward were formed of the higher beds, all nearly horizontal and resting quite unconformably on the Ecca Beds. These ranges had been carved out by denudation, which had removed the Molteno, Karoo, and Stormberg Beds to the south and north. The view advocated by Mr. Dunn that the Kimberley Beds north of the ranges represented the Ecca Beds to the south was discussed, and the author gave reasons for dissenting from it, and classing the Kimberley Beds as a higher subdivision.

Some notes on more recent formations, the conglomerates of Oliphant's River and superficial deposits, were followed by a summary of the author's conclusions as to the probable geological history of South Africa. The Bokkeveldt Beds are shown by their fossils to be marine, and possibly all the formations up to the Zuurberg Quartzite may be also marine. The Ecca Beds have yielded no fossils which would enable us to decide whether they are marine or freshwater; the Kimberley, Karoo, and Stormberg Beds are looked upon as lacustrine.

3. "On Two New Lepidotoid Ganoids from the early Mesozoic Deposits of Orange Free State, South Africa." By A. Smith Woodward, Esq., F.G.S.

Of the two species of fishes described in the present paper, one was founded on specimens of four individuals brought to England by Dr. H. Exton in 1883, together with the types of *Tritylodon* and *Rhytidosteus*, the other on two examples recently received from the same source. Both were from the Stormberg Beds of the Upper Karoo series.

After giving further details of the structure of both forms, and describing the head and opercular fold, appendicular skeleton and

scales in each, the author showed that one species must be referred to the genus *Semionotus*, and was most nearly allied to the American types referred by Sir P. Egerton to *Ischypterus*. For this species the name of *Semionotus capensis* was proposed.

The other species agreed in its characters with the Platysomidæ, and was especially allied to the genus *Tetragonolepis*; but the nearest ally of all was a fish from the Hawkesbury Beds of Australia, *Clithrolepis granulatus*. The name of *Clithrolepis Extoni* was proposed for the new South African species.

II.—February 8, 1888.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "On some Remains of *Squatina Cranei*, sp. nov., and the Mandible of *Belonostomus cinctus*, from the Chalk of Sussex, preserved in the Collection of Henry Willett, Esq., F.G.S., Brighton Museum." By A. Smith Woodward, Esq., F.G.S.

The remains referable to *Squatina* consist of a crushed skull, with the mandibular and hyoid arches, and an associated fragment of the pectoral fin with dermal tubercles. The fish was probably about 30 inches long. There are some difficulties in the way of interpretation, but the form and relative proportions of the cranium, etc., appear to be similar to those of the living representative of the genus. The dentition is not completely preserved; the teeth near the symphysis of the mandible are relatively high and slender, while the opposing teeth are small. The great relative size of the spinous dermal tubercles serves to distinguish it from species of *Squatina* already known. The anterior lower teeth are also more slender than in the existing *S. angelus*.

No specimen of *Belonostomus* has hitherto revealed the precise characters of the dentition or the relations of the hindermost bones. This deficiency is now supplied. The two rami occupy only one half the entire length of the jaw, the anterior half being formed by the elongated presymphysial bone, which is provided with a powerful prehensile dentition. The character of the teeth was described by the author: the large median teeth end abruptly at the posterior extremity of the presymphysial element, but the small lateral teeth are continued backwards upon the rami of the jaw, increasing in size and becoming relatively shorter. Further details were given, and the evidence shows that the original specimens described by Agassiz, as portions of the mandibular rami of *Belonostomus cinctus*, are really fragments of the presymphysial bone of this species. Some of the relations of *Belonostomus* and *Aspidorhynchus* were pointed out.

2. "On the History and Characters of the Genus *Septastræa*, D'Orbigny (1849), and the Identity of its Type Species with that of *Glyphastræa*, Duncan (1887)." By George Jennings Hinde, Ph.D., F.G.S.

D'Orbigny founded the genus *Septastræa* on the characters of a coral from the Miocene strata of Virginia, which was named *S. subramosa*, but no specific description was given. In the same year (1849), Edwards & Haime accepted the genus as valid, but placed

S. subramosa as a synonym of *Astræa ramosa*, Defrance—an apparently *recent* species of coral which had previously only been informally described by Defrance. They also included in the genus *S. Forbesi*, the original specimen of which was from the Miocene of Maryland, and at that time in the collection of the Geological Survey in London. Later on, in 1852, D'Orbigny claimed that *S. Forbesi* was but a synonym of his *S. subramosa*. There is good reason for regarding this as correct, but owing to the fact that D'Orbigny's name *subramosa* was merely nominal and without description, the later name of *S. Forbesi*, Edwards & Haime, must be allowed to stand for the type of the genus *Septastræa*.

In 1861 de Fromentel, and in 1867 Prof. Duncan, included in *Septastræa* several species of Jurassic and Liassic corals, which, however, have no generic relationship to the type form of the genus from the Miocene Tertiary.

In 1887 Prof. Duncan read a paper before the Geological Society, in which he adopted *Septastræa Forbesi*, E. & H., as the type of a new genus *Glyphastræa*, thus leaving in *Septastræa* those Liassic and Jurassic species placed therein by himself and de Fromentel. As this proceeding is contrary to recognized rules of nomenclature, the genus *Glyphastræa* will have to be abolished.

In the type form of *Septastræa*, now in the British Natural-History Museum, the walls of the corallites, though closely apposed, are quite distinct; the theca is formed by the extension of the septal laminæ; the walls and septa in the lower portion of the corallites are very thin, but the upper portion of the corallites are so infilled with compact stereoplasm that the calices are extremely shallow when mature. There is no true columella, only a pseudo-columella, formed by the union and partial involution of the inner septal margins. The increase is inclusively by marginal gemmation; fission does not occur. In some cases linear perforations between the septa are shown; these appear to be for the insertion of the mesenterial muscles.

Tha septa in *Septastræa* consist of a central layer, dark in microscopic sections, the primary layer of v. Koch or centre of calcification of Bourne and Fowler, enclosed on both sides by layers of compact subcrystalline stereoplasm. In longitudinal fractures the septa frequently split in the centre of the dark or primary layer, and thus show that each half of the septum consists of a dark and light portion, and the median face of each septal lamina exhibits transverse growth-lines, not unlike those of an epitheca, beneath which are delicate longitudinal ridges and grooves. The thecal wall has a similar structure to that of the septal laminæ, of which it is an extension.

There is a close correspondence in the septal and thecal structure of *Septastræa* to that of the recent and fossil genus *Flabellum*, and in this genus also the septa occasionally split longitudinally and show the same growth-lines on their median faces.

Only two species are included in *Septastræa*, as now defined, viz. *S. Forbesi*, E. & H., and *S.* (*Columnaria?*) *sexradiata*, Lonsdale, sp.

3. "On the Examination of Insoluble Residues obtained from the Carboniferous Limestone at Clifton." By E. Wethered, Esq., F.G.S. The author noticed previous classifications of the Carboniferous Limestone at Clifton, and submitted the following for reference in the present paper:—

Carboniferous Limestone Series.

			feet
Stage C.	Upper Limestones		100
„ B.	Middle Limestones		1620
„ A.	Lower Limestones:—		
	1. Black Rock	490	
	2. Lower-Limestone Shales	500	
			990
	Total		2710

The limestone-forming organisms in each of the above were mentioned, and the methods adopted for obtaining the insoluble residues by means of hydrochloric acid were described. A table of percentages of insoluble residues was given from the Lower Limestone Shales and Black Rock, from the Oolitic Beds, *Mitcheldeania*-beds, and main portion of the Middle Limestones, and from the Upper Limestones.

Detrital quartz of small size, with a few grains of felspar, tourmaline, and zircon, characterize the Lower-Limestone Shales, and in one variety the soft tissues of organisms are represented by ferric oxide, which in the case of crinoids represents the whole skeleton. Residues of the Black Rock exhibit slight secondary crystallization round detrital quartz, whilst amorphous and chalcedonic silica become more plentiful. Residues of the Middle Limestone consist to a less extent of detrital quartz along with micro-crystals of quartz, amorphous and chalcedonic silica, and less frequently of pyrites, tourmaline, and zircon; sponge-spicules are also noted. Towards the top of the Middle Limestones the proportion of detrital quartz increases, and the deposit of secondary silica on the surface of quartz-grains is less marked.

The nature of the amorphous and chalcedonic silica in the limestone, and the relations of this silica to the small quartz-crystals, were also discussed. The latter were shown in some instances to possess nuclei of detrital quartz, and where this is not the case, to have resulted from the crystallization of amorphous silica.

Geologists' Association.

December 2nd, 1887.—F. W. Rudler, Esq., F.G.S., President, in the Chair.—The following communication was read:—

"A Synopsis of the Vertebrate Fossils of the English Chalk," by A. Smith Woodward, F.G.S., F.Z.S.

The author reviewed in succession the various genera of fossil vertebrata hitherto recorded from the English Chalk, adding full references to the literature of the subject, British and Foreign. A careful examination of the type-specimens and numerous other fossils in the British Museum, Brighton Museum (Willett Collection),

Woodwardian Museum, the Museum of Practical Geology, and the private cabinets of Mr. S. J. Hawkins, F.G.S., and other members of the Association, had suggested several emendations in the already accepted nomenclature of the genera and species, besides adding a few new forms, either now described, or deferred for description to a future occasion. The revised list is as follows, with synonyms in brackets :—

REPTILIA.

Order CHELONIA.
- (?) *Chelone Hoffmanni*. [*Chelone Camperi*, Owen.]
- *Cimoliochelys Benstedi* (Mantell), Owen. [*Emys Benstedi*, Mantell.]

Order SAUROPTERYGIA.
- *Polyptychodon continuus*, Owen.
- ,, *interruptus*, Owen.
- *Plesiosaurus Bernardi*, Owen.
- ,, *constrictus*, Owen.
- ,, *Smithii*, Owen.

Order ICHTHYOSAURIA.
- *Ichthyosaurus campylodon*, Carter.

Order PYTHONOMORPHA.
- *Mosasaurus anceps* (Owen). [*Leiodon anceps*, Owen. *Mosasaurus stenodon*, Charlesworth.]

Order LACERTILIA.
- *Dolichosaurus longicollis*, Owen.
- *Coniosaurus crassidens*, Owen.
- *Rhaphiosaurus subulidens*, Owen. [*R. lucius*, Owen.]

Order PLESIOSAURIA.
- *Ornithocheirus giganteus* (Bowerbank). [*Pterodactylus giganteus*, Bow., *Cimoliornis diomedeus*, Owen, *Pterodactylus conirostris*, Owen.]
- ,, *Cuvieri* (Bowerb.) [*Pterodactylus Cuvieri*, Bowerb.]
- ,, *compressirostris* (Owen). [*Pter. compressirostris*, Owen.]

PISCES.

Order SELACHII.
- *Acrodus* (?) *Illingworthi*, Dixon. [? *Hybodus*.]
- *Corax falcatus*, Agass. [*Corax maximus*, Dixon.]
- ,, *pristodontus*, Agass.
- *Drepanephorus major* (Agass.), Egert. [*Spinax major*, Agass., *Cestracion canaliculatus*, Egert., *Drepanephorus canaliculatus*, Egert., *Acrodus cretaceus*, Dixon, (?) *Acrodus rugosus*, Agass.]
- *Hybodus dubrisiensis*, Mackie.
- *Notidanus microdon*, Agass.
- ,, *pectinatus*, Agass.
- *Odontaspis rhaphiodon*, Agass.
- ,, *subulata*, Agass.
- *Otodus appendiculatus*, Agass.
- ,, *crassus*, Agass.
- ,, *semiplicatus*, Münster.
- *Oxyrhina crassidens*, Dixon.
- ,, *Mantelli*, Agass. [*Lamna acuminata*, Agass.]
- *Ptychodus decurrens*, Agass. [*Ptych. depressus*, Dixon.]
- ,, *latissimus*, Agass. [*Ptych. paucisulcatus*, Dixon.]
- ,, *mammillaris*, Agass. [*Ptych. altior*, Agass.]
- ,, *Oweni*, Dixon.
- ,, *polygyrus*, Agass. [*Aulodus Agassizii*, Dixon, *Ptych. latissimus*, Agass. in part.]
- ,, *rugosus*, Dixon. [*Ptych. altior*, Dixon, *non* Agass.]
- *Scylliodus antiquus*, Agass.
- *Squatina Cranei*, A. S. Woodw.

Order CHIMÆROIDEI.

Edaphodon Agassizii, Buckl.
,, *crassus*, Newton.
,, *gigas*, Egert.
,, *Mantellii*, Buckl.
,, *Sedgwickii*, Agass.
Elasmodectes Willetti, Newton. [*Elasmognathus*, Newton *non* Gray.]
Ischyodus brevirostris, Agass. (var.)
,, *incisus*, Newton.

Order GANOIDEI.

Belonostomus attenuatus, Dixon.
,, *cinctus*, Agass.
Cœlodus angustus (Agass.), Zittel. [*Gyrodus angustus*, Agass.]
,, *cretaceus* (Agass.), Zittel. [*Pycnodus cretaceus*, Agass.]
,, (?) *faba* (Agass.), Zittel. [*Acrotemnus faba*, Agass.]
,, *parallelus* ((Dixon), Zittel. [*Pycnodus parallelus*, Dixon.]
Gyrodus cretaceus, Agass. [*Gyrodus conicus*, Dixon.]
Lophiostomus Dixoni, Egert.
Macropoma Mantelli, Agass. [*Amia ? lewesiensis*, Mantell.]
Microdon (?) *occipitalis*, Dixon.
Neorhombolepis excelsus, gen. et sp. nov.
Prionolepis angustus, Egert.
Gen. non det. [*Lepidotus punctatus*, Agass. MS.]

Order TELEOSTEI.

Acrognathus boops, Agass.
Aulolepis typus, Agass.
Berycopsis elegans, Dixon.
Beryx radians, Agass.
,, (?) *microcephalus*, Agass.
Calamopleurus anglicus, Dixon.
Cimolichthys levesiensis, Leidy. [*Saurodon Leanus*, Agass. *non* Hays.]
Cladocyclus levesiensis, Agass.
Daptinus intermedius, Newton.
Dercetis elongatus, Agass.
Enchodus levesiensis (Mantell), Agass. [*Esox lewesiensis*, Mantell, *Enchodus halocyon*, Agass.]
Homonotus dorsalis, Dixon.
Hoplopteryx levesiensis (Mantell). [*Zeus lewesiensis*, Mantell, *Beryx ornatus*, Agass.]
,, *superbus* (Dixon). [*Beryx superbus*, Dixon.]
Ichthyodectes elegans, Newton.
,, *minor* (Dixon), Newton. [*Hypsodon minor*, Dixon.]
Osmeroides levesiensis (Mantell), Agass. [*Salmo lewesiensis*, Mantell.]
,, (?) *crassus*, Dixon.
Pachyrhizodus basalis, Dixon.
,, *Gardneri* (Mason), W. Davies MS. [*Hypsodon lewesiensis*, Ag., in part, erroneously described and figured. *Acrodontosaurus Gardneri*, Mason.]
,, *gracilis* (Owen), W. Davies MS. [*Mosasaurus gracilis*, Owen.]
Platax nuchalis (Dixon), A. S. Woodw. [*Microdon nuchalis*, Dixon.]
Plethodus expansus, Dixon.
,, *oblongus*, Dixon.
Plinthophorus robustus, Günther.
Pomognathus eupterygius, Dixon.
Portheus Mantelli, Newton. [*Hypsodon lewesiensis*, Agass. in part.]
,, *Daviesii*, Newton.
,, sp. ind. [*Hypsodon lewesiensis*, Agass. in part.]
Protosphyræna ferox, Leidy. [*Saurocephalus lanciformis*, Agass., *non* Harlan. *Xiphias Dixoni*, Leidy. *Erisichthe Dixoni*, Cope.]
,, *minor* (Agass.), A. S. Woodw. [*Tetrapterus minor*, Agass.]
Saurocephalus (?) *striatus*, Agass.
Stenostoma pulchella, Dixon.
Stratodus anglicus, sp. nov.

Tomognathus mordax, Dixon.	[*Tom. leiodus*, Dixon.]
Elopine Clupeoid, gen. non det.	
INCERTÆ SEDIS.	
Cœlorhynchus cretaceus, Dixon.	
Ancistrodon, sp.	
Pelecopterus spectabilis (Agass.), Cope.	[*Ptychodus spectabilis*, Agass.]
,, *gibberulus* (Agass.), Cope.	[,, *gibberulus*, Agass.]
,, *arcuatus* (Agass.), Cope.	[,, *arcuatus*, Agass.]
,, (?) *articulatus* (Agass.), Cope.	[,, *articulatus*, Agass.]

The author also pointed out that the type specimen of *Strophodus asper*, Agass., is a fragment of a Crustacean; that the so-called *Orthagoriscus*-jaw (Dixon) is the dentary bone of a Chelonian; that *Selache Daviesii*, Hasse, is founded upon a vertebra of *Ptychodus*; and that the so-called premaxilla of *Enchodus* is really the palatine bone.

CORRESPONDENCE.

THE DIMETIAN OF ST. DAVIDS.

SIR,—The geology of St. Davids will, I fear, never be settled by petrological methods. Recognizing this, I based my interpretation of the so-called Dimetian principally upon the relation and disposition of the various groups of rocks composing the peninsula of St. Davids. The result of my examination was to lead me to believe that by no known system of faults and folds could the "Dimetian," if a pre-Cambrian body, have been placed in its present relations with the surrounding rocks. This is my main contention, and all the remaining arguments are subsidiary, and in value only relative. As I have already developed these views in detail in a paper just read before the Liverpool Geological Society, I need not further dwell upon them here.

It is very far from my intention of entering upon a controversy upon this question, most of all from a petrological standpoint. On a re-perusal of the literature on this subject, I find that Dr. Hicks formerly described as shales interbedded in the Dimetian what he now considers to be Diabase Dykes.

I may be quite wrong in my view that the veins in question are included Cambrian shales; but until I have an opportunity of re-examining the district, I am not prepared to admit his contention.

PARK CORNER, BLUNDELLSANDS, T. MELLARD READE.
11th January, 1888.

THE EXTENT OF THE HEMPSTEAD BEDS, ETC.

SIR,—Writing in the Isle of Wight,[1] with no library available, I find I have overlooked a paper by Dr. E. P. Wilkins, F.G.S. As long ago as 1861 he recorded a section of Hempstead Beds in the Medina (see Proc. Geol. Assoc. vol. i. p. 194).

CLEMENT REID.

[1] GEOL. MAG. NOV. 1887.

MISCELLANEOUS

British Petrography.

It may interest our petrological readers to learn that the remaining portion of Mr. Teall's admirable "British Petrography" is in the press, and will shortly appear. The issue in monthly parts, as originally contemplated by Mr. Teall, had, in consequence of an unforeseen contingency, to be discontinued. The firm of publishers that had undertaken to bring out the work became involved in financial difficulties, and ultimately failed, placing Mr. Teall in the remarkable predicament of having to purchase a portion of his own book. We are happy to be able to state that the work is now in good hands, namely, those of Messrs. Bemrose & Son, and is only awaiting the completion of a few of the plates, before being given to the scientific world. We must congratulate the author on having brought to a favourable conclusion an undertaking as comprehensive in design as it is thorough in execution. The 200 pages which have already appeared, replete with accurate and minute description, well furnished with references to original sources and illustrated by plates of surpassing beauty, have been sufficient to place the book in the front rank of petrographical literature, among such classic compeers as Fouqué and Lévy's "Minéralogie Micrographie," Rosenbusch's "Physiographie der Mineralien und Gesteine," and Zirkel's "Lehrbuch der Petrographie."

OBITUARY.

FERDINAND V. HAYDEN.

Born September, 1829; Died 23rd December, 1887.

Dr. F. V. Hayden was born in Westfield, Mass., in 1829. He was a graduate of Oberlin College, Ohio, and received the degree of Doctor of Medicine from the Medical School of Albany, N.Y., in 1853. He was surgeon in the army during the civil war; and after it for seven years, he held the position of Professor of Mineralogy and Geology in the University of Pennsylvania.

But the larger part of his time, from 1853 to the close of 1878, an interval of twenty-six years, was spent in Rocky Mountain exploration, in which his special work was geological; and through his labours and the investigations of those associated with him, a wide extent of territory, until then little studied, was examined geologically and topographically. Coal-beds were found and a new coal-flora made known, new fossil Mammals, Reptilia, and Fishes, in great numbers, were collected and described, the stratigraphy and palæontology of the Cretaceous and Tertiary and the intermediate Laramie or Lignite beds were well investigated, and the Yellowstone Geyser region brought to notice and explored.

Dr. Hayden's personal work consisted in a general geological reconnaissance of the regions visited, the collection of fossils, which was the chief object of the earlier expeditions, and the supervision and direction of the surveying parties. He was the first to make known the facts as to the vast Tertiary lake-areas of the summit

region and eastern slopes of the Rocky Mountains, whence he drew the conclusion that the elevation of the mountains went on slowly through the whole Tertiary, commencing with the Laramie, which afforded some brackish-water fossils.

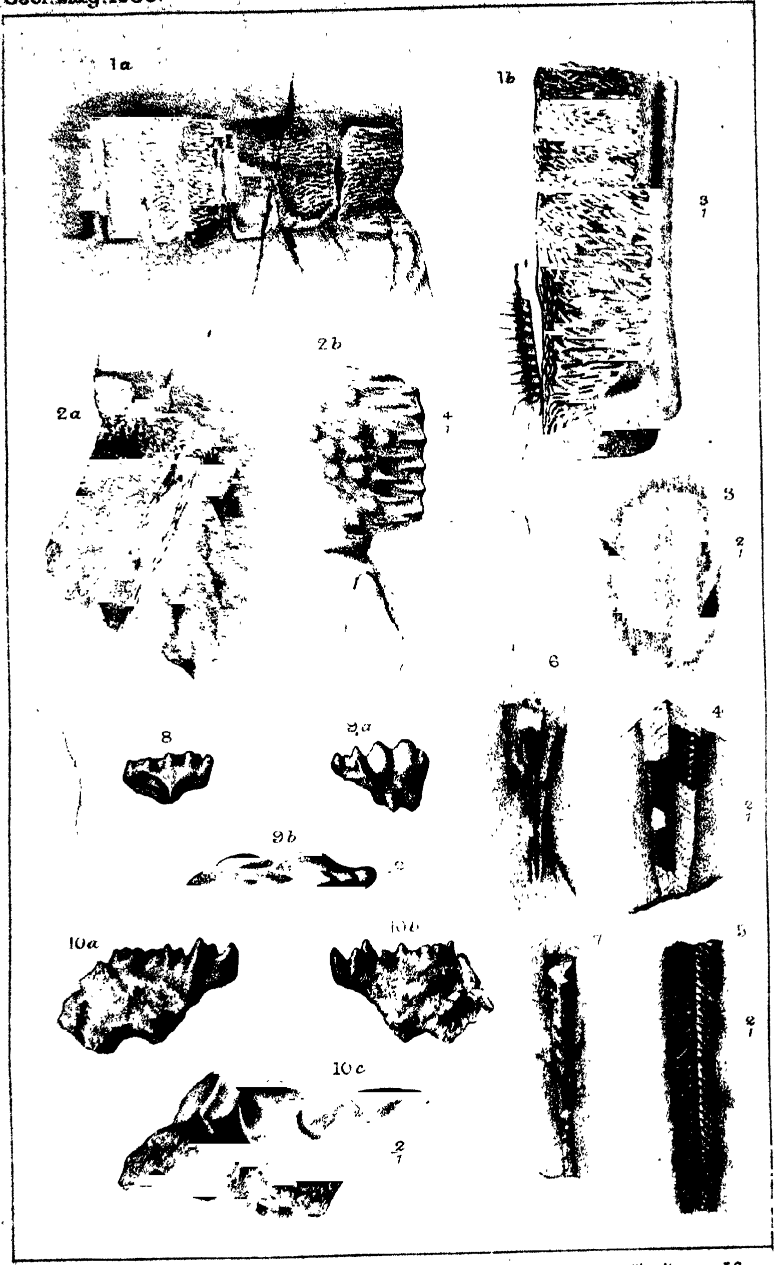
His first two expeditions were made in 1853 and 1855 to the Bad Lands on White River, in Dakota, that of 1853 at the expense of Professor James Hall. Large collections of remains of fossil mammals were brought home, besides numerous other species. His palæontological friend, Mr. F. B. Meek, was with him. In 1857 he accompanied Lieut. G. K. Warren's expedition, and made the discovery of the rich Niobrara Mammalian fauna, newer than the White River, and obtained a great number of specimens. In 1866 he visited the "Bad Lands," making collections for the Academy of Natural Sciences of Philadelphia. The mammalian remains obtained in these various expeditions, along with those gathered by Dr. John Evans in 1849 and 1853, and Mr. Culbertson 1850, were the materials used by Dr. Leidy for his great work on the Extinct Fauna of Dakota and Nebraska (1869).

During 1859 and 1860, Dr. Hayden was connected, as geologist, with Capt. Raynold's expedition to the headwaters of the Yellowstone and Missouri. In 1867, after the civil war, the series of government expeditions under his charge was begun that continued through the consecutive years to the close of 1878. By these expeditions his explorations became extended over large parts of Nebraska, Dakota, Colorado, Utah, Wyoming, Montana, New Mexico, and Kansas. The first appropriation was only 5000 dollars; but the later were more liberal, and besides his regular corps, a number of other scientists sometimes accompanied the exploration. Mr. Meek accompanied him, and through him large numbers of invertebrate species of the Cretaceous, Tertiary, Jurassic, and other formations were figured and described; and precision was thus given to the fac[illegible] o[illegible] [illegible]uccess in laying down the subdivisions of these formations and [illegible]ing their distribution. After the death of Mr. Meek in December, 1876, his department passed under the charge of Dr. C. A. White. Mr. L. Lesquereux investigated, figured and described the fossil plants of the Laramie and other formations. Dr. Cope joined the expeditions of 1872 and 1873 and afterwards described the vertebrate fossils, collected in these and later years, in two quarto volumes.

The many volumes of the expedition, in 8vo. 4to. and the atlases, need not here be enumerated. Dr. Hayden had reason for feeling gratified with the great scientific results obtained by the expeditions under his charge, and the wonderful discoveries made concerning the ancient life of the continent, its vast mineral resources, and the successful mapping of its topographic features.

Since the expedition closed in June, 1879, Dr. Hayden has resided in Philadelphia.

Dr. Hayden was a member of the National Academy of Sciences, and received various honours from academies abroad. He was elected a Foreign Member of the Geological Society of London in 1879.—*Silliman's Amercian Journal.*



E. C. Knight lith. West, Newman & Co imp.

Scandinavian Phyllocarida.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. V.

No. IV.—APRIL, 1888.

ORIGINAL ARTICLES.

I.—On Some Scandinavian Phyllocarida.

By Prof. T. Rupert Jones, F.R.S., and Dr. Henry Woodward, F.R.S.

(PLATE VI.)

(*Continued from page* 100.)

7. The Gastric Teeth of Ceratiocaris. Pl. VI. Figs. 8, 9, 10; and Woodcuts, Figs. 1–9.

In the Geological Magazine, Vol. II. 1865, p. 401, some account was given of the curious gastric teeth of *Ceratiocaris* and *Dithyrocaris*, from the Upper-Ludlow and Carboniferous strata of Scotland and Ireland; and in the *Article* Crustacea, by the same author, in the "Encyclopædia Britannica," vol. vi. 1877, p. 639, fig. 13, the relationship of such internal masticatory organs to the stomach of the Crab and Lobster, in particular, was treated in detail.

Bohemian specimens.—The late M. Barrande, in his "Syst. Silur. Bohême," vol. i. Supplm. 1872, p. 443, plates 18, 21, and 31, described and figured several gastric teeth, presumably of more than one species of *Ceratiocaris*, which he had obtained from his "Stage E-e 2," equivalent to the lower divisions of Murchison's "Upper Silurian." These little fossils were found in the same beds with *Ceratiocarides*,[1] but could not with certainty be referred to their species. He described them as having a general resemblance among themselves, being somewhat crescent-shaped, slightly concave on one side and convex on the other, with the middle part thicker than the ends. He does not appear to have met with any having a basal, root-like or fang-like portion attached. The number of cusps observed by M. Barrande nearly always amounted to six, the exceptions being perhaps due (he thought) to the age of individuals.

In some of the forms from Bohemia each cusp (seen from above) has the shape of a chevron, more or less distinct according to its place in the series; the strongest being in the middle, and the weakest towards the ends. Each chevron is hollow and sloping, with sharp borders. Thus, seen from above, the surface has a sharp, flexuous or zigzag ridge; each bend forming a chevron and cusp. When perfect, there is a sharp point at the top of the chevron of each cusp, and often a smaller tubercle at each of its lower ends. In his pl. 21, figs. 41, 42, and 43, the chevrons of this zigzag ridge usually open

[1] The species of Phyllocarida found in this Stage were *Ceratiocaris Bohemica*, *C. docens*, *C. inæqualis*, with *Aristozoë inclyta* and *A. Jonesi*.

towards the concave side, and their summits are towards the convex side. In fig. 44, and in others not figured, the reverse occurs; and M. Barrande could not say if the difference were of generic or only of specific value. Possibly the difference may have been due to the right or left position of the "tooth" when in place. Fig. 41 (9 mm. long) was found in the same strata with *C. inæqualis*, Barr. Fig. 42 is 8 mm. long (Woodcut, Fig. 2), and fig. 43 is imperfect; these were found in the strata with *C. Bohemica*, Barr. Fig. 44 (not quite perfect) is 14 mm. long. In pl. 18, fig. 2 (15 mm. long) differs somewhat from the others; it looks more complicated, but has been perhaps decomposed into vertical parallel layers, concentric with the chevrons. The specimen in figs. 3 and 4 (30 mm. long) is obscure. Fig. 5 (24 mm.) shows four large cusps on one (concave?) side; and six on the other, smaller, and perhaps representing the opposite ends of the chevrons. In pl. 31, fig. 21 (22 mm.) shows what appear like two nearly perfect rows of blunt cusps.

Scandinavian specimens.—The "teeth" from Fårö, Gothland, represented in our Pl. VI. Figs. 9 and 10, and Woodcuts, Figs. 1, 3, 4, belong apparently to two kinds. Figs. 10 *a*, *b*, *c*, are evidently related to those with cusps of a chevron-shape when looked at from above, and already referred to as described in M. Barrande's "Syst. Sil. Bohême." The chevrons, however, are less sharply angular in the flexuous ridges of the northern specimens (Fig. 10 *c*), and the cusps are not only less regular, but are much larger, higher, and sharper at one end of the tooth than the other (Figs. 10 *a*, *b*, *c*).

Fig. 8 (13 mm. long) shows five cusps of nearly equal size; and seen from above they appear to be united by a sharply-angular and regular zigzag ridge (Woodcuts, Figs. 1*a*, 1*b*), as in Barrande's figs. 41, 42 (Woodcut, Fig. 2), and 44. His figures unfortunately do not give the side view for comparison,—only an imperfect vertical section, fig. 43.

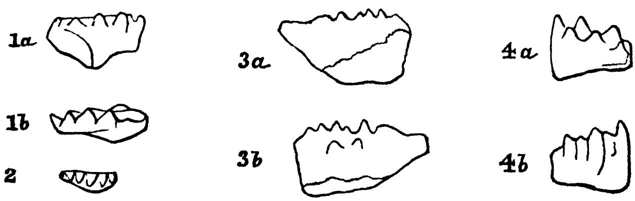


Fig. 1 *a*. Side view of a "tooth"; the same as Pl. VI. Fig. 8. From Fårö. Nat. size.
" 1 *b*. The same, seen from the top edge.
" 2. A somewhat similar "tooth," seen from the top. Barrande's pl. 21, fig. 42 *a*, p. 443. From the Stage E of Bohemia. Nat. size.
" 3 *a*. Side view of a "tooth." From Fårö. Nat. size.
" 3 *b*. The other side of the same.
" 4 *a*. Side view of a "tooth." From Fårö. Nat. size.
" 4 *b*. The other side of the same.

Pl. VI. Fig. 9 *a*, *b* (14 mm. long) presents another shape altogether, inasmuch as the cusps keep nearly all in a single row without the

flexuous or zigzag ridge. They are six in number, blunt, and differing much in size one from another; the middle of the body of the "tooth" is thicker than the ends.

Two other specimens from the same locality have the cusps more distinctly arranged in two rows and somewhat alternating (Woodcuts, Figs. 3 and 4). These in some respects approach fig. 21 in Barrande's pl. 31. One of them is 17 mm., and the other (imperfect?) 10 mm.

All the Scandinavian specimens of Crustacean teeth here mentioned are from the Upper Silurian of the Isle of Fårö, off the North-eastern extremity of Gothland.

British specimens.—Fossil carapace-valves having irregular marks due to the presence of "teeth" within the squeezed valves of the carapace are not unusual in the collections from Lanarkshire. In the British Museum, "No. 58878," from Linburn, near Muirkirk, Lanarkshire, is a specimen showing a pair of "teeth," each 8 mm. long, with six cusps, longer at one end of the "tooth" than the other (Woodcut, Fig. 7). Also another, "No. 45160," figured in the GEOL. MAG. 1865, Pl. XI. Fig. 2, from Lesmahago (Woodcut, Fig. 5). This measures 9 mm. long, and has an oblique basal portion, 10 mm. long. In the University Museum at Cambridge are two specimens. One of them, "*b*/11," imperfect, with only four, rather long and irregular cusps (Woodcut, Fig. 7), is from Beck Mills, near Kendal (Upper-Ludlow Beds), and measures 6 mm. in length; and the other, "*b*/136," from Lesmahago, Lanarkshire, has seven cusps, and is 12 mm. long, with an oblique root 15 mm. long; the cusps are high and sharp at one end, and small and blunt at the other (Woodcut, Fig. 6). Referring to GEOL. MAG. 1865, we see in Pl. XI. Fig. 1 (*Ceratiocaris papilio*, also from Lesmahago) that the "teeth" are made to appear as being opposed one to the other vertically (Woodcut, Fig. 9); this is, without doubt, due to the compression of the carapace, and to their being squeezed against the inside of the valves. In their normal position they would be opposed to each other horizontally, or nearly so. As regards the shape of these "teeth," they resemble that of the others in the British Museum and those in the Cambridge Museum. In the Glasgow University Museum a fine example of *C. stygia* has similar teeth, also placed within the anterior portion of the carapace. All of these, however, have their cusps smaller and more regular than those in our Pl. VI. Fig. 10; they do not quite agree with our Fig. 8, which is probably allied to Barrande's pl. 21, figs. 41-44 (judging chiefly from the upper surface); and they differ much from our Pl. VI. Fig. 9.

The specimens in the British Museum (Nos. 45160 and 58878), and the more perfect specimen of the two in the Cambridge Museum, differ materially from the Bohemian and Scandinavian specimens in the more trenchant character of their cutting edges, and in the broad elongated bases of attachment, suggesting that we may be here dealing with two forms of masticatory organs,—namely, (1) a thicker

and more solid form, being probably true gastric teeth; and (2) a compressed trenchant type, being a portion of the true mandible. Some, indeed, of the European forms also may have belonged to this latter type; but, as the bases (if ever existent) have been broken off in the Gothland examples, and hidden in the figures of those from Bohemia, we are unable to speak with confidence as to this part of their structure. The differences, moreover, in the material in which they have been imbedded, and in the conditions of pressure and fossilization, may have modified the organisms to a very considerable degree.

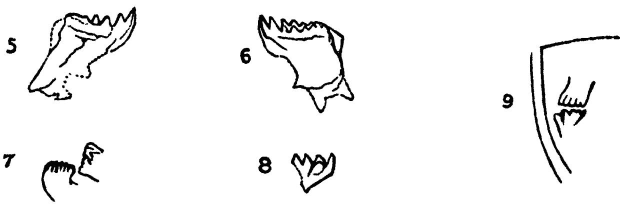


FIG. 5. Specimen "45160" in British Museum. From Lesmahago. Nat. size.
,, 6. Specimen "*b*/136" in Cambridge Museum. From Lesmahago. Nat. size.
,, 7. Specimen "58878" in British Museum. From Lesmahago. Nat. size.
,, 8. Specimen "*b*/11" in Cambridge Mus. From Beck Mills, Kendal. Nat. size.
,, 9. Part of specimen "47989" in the British Museum, showing the position of the "teeth" in the anterior region of the carapace of *Ceratiocaris papilio*. From Lesmahago, Lanarkshire. Nat. size.

We cannot pretend to refer these fossil teeth to the known species of *Ceratiocaris*; but evidently there are six different forms; thus:—

1. With neatly chevron-shaped cusps, regular in size. Woodcut, Fig. 2. Barrande's pl. 18, f. 2 (?); pl. 21, f. 41–44; and Pl. VI. Fig. 8.
2. Small neat cusps, longer at one end of the tooth than at the other. Woodcuts, Figs. 5, 6, 7, 8 (?), 9.
3. Cusps with a more flexuous connecting ridge. Pl. VI. Figs. 10 *a*, 10 *b*, 10 *c*.
4. Cusps in two parallel rows, but somewhat alternate. Barrande's pl. 31, f. 21.
5. Cusps irregularly alternate in two rows. Woodcuts, Figs. 3 and 4.
6. Cusps in a single row. Pl. VI. Figs. 9 *a*, 9 *b*.

Note.—It may be well to mention that in the "Quart. Journ. Geol. Soc." vol. xvii. 1861, pp. 542–552, pl. 17, Dr. J. Harley described and figured numerous small, waterworn, organic fragments from the Ludlow Bone-bed, under the generic name of *Astacoderma*; and he referred them to a Crustacean origin, mostly as being morsels of the harder parts of tests and limbs, but in two instances as having some resemblance to "the stomach-teeth of the common Lobster" (p. 550, pl. 17, figs. 11–13). In "Siluria," 3rd (called the "4th"), edit. 1867, p. 542, it was suggested that all the specimens figured by Dr. Harley, excepting figs. 15 and 16, were really portions of the teeth of Phyllopod Crustaceans such as *Ceratiocaris*.

II. Phasganocaris, Novák.

Sitzungsb. k. böhm. Gesell. Wissensch. 1886, p. 1, pl. i.

1. Phasganocaris pugio (*Eurypterus*, Barrande [1]), Novák. *Loc. cit.*

1[a]. Phasganocaris pugio (Barrande), var. serrata, J. & W. Plate VI. Figs. 3–7.

Fifth Report on the Palæozoic Phyllopoda, 1887, p. 3; Report Brit. Assoc. for 1887 (1888), p. 62.

Four flattened pieces (Figs. 3–6) of tapering, riband-like telsons, with a central line, sometimes raised, but usually sunken, which was originally a ridge in all probability. From it, on each side, numerous parallel, oblique, sigmoid lines pass downwards and outwards, and these end at the edges with sharp upward curves, defining the small sub-triangular teeth of a serrated fringe. This is of varying strength, and is sometimes backed by a slight ridge. Except in the serrated edges these specimens correspond in essential particulars with the *dorsal* aspect of the triangular or bayonet-like lower portion of the telsons referred by Barrande to *Eurypterus*, but by O. Novák, lately and with precision, to his new genus *Phasganocaris*.

These fragments, dark brown and chitinous in appearance, are in an earthy yellowish-grey limestone (Lower Ludlow) from Vattenfallet (the Waterfall) near Wisby, Gothland.

Fig. 7 shows a longer and narrower piece of a telson, badly preserved, much crushed and wrinkled, but retaining some convexity, and its upper end showing a slightly triangular section. It is dark-brown and chitinous, in a blue-grey, calcareous, and finely micaceous shale (of the Ludlow series), from the Ringsjön, Scania.

EXPLANATION OF PLATE VI.

Fig. 1. *Ceratiocaris Scharyi*, Barrande. 1 *a*, abdominal segments; nat. size. 1 *b*, one of the segments and part of another, magnified 3 diam. The Ringsjön, Scania.

" 2. *C. pectinata*, J. & W. 2 *a*, ultimate segment, telson (style), and one stylet; nat. size. 2 *b*, a portion of the segments, magnified 4 diam. The Ringsjön.

" 3, 4, 5. *Phasganocaris pugio* (Barr.), var. *serrata*, J. & W. Portions of telsons, magnified 2 diam., and Fig. 6, nat. size. From Vattenfallet, Wisby, Gothland.

" 7. *P. pugio*, var. *serrata*, J. & W., nat. size. From the Ringsjön, Scania.

" 8. Tooth of *Ceratiocaris*; side view; nat. size.

" 9. Tooth of *Ceratiocaris*. 9 *a*, side view; nat. size. 9 *b*, top view; magn. 2 diam.

" 10. Tooth of *Ceratiocaris*. 10 *a* and 10 *b*, side views; nat. size. 10 *c*, top view. Magn. 2 diam.

Figs. 8–10 are from the Isle of Fårö, north of Gothland.

Supplemental Note on Ceratiocaris Angelini. Pl. V. Fig. 1.

Prof. Lindström has favoured us with a careful sketch of the ridges and pits seen on the original specimen of *Ceratiocaris Angelini*, J. & W., but very obscure on the plaster cast. He writes (Mar. 2): " The tip of the telson in *Cer. Angelini* is only slightly longer than

[1] *E. pugio*, Barr. Sil. Syst. Bohême, vol. i. Suppl. p. 564, pl. xxvi. figs. 25–34, and pl. xxxiv. figs. 7–9.

that of the plaster cast. Its total length is 148 mm., and there is thus a difference of only 7 mm. between the original and your figure. I enclose a fairly good sketch of the row of impressions on the left side of the telson as seen in the original. They are visible for a length of 57 millim. from the broken tip upwards and are very small, about 14 being contained within a length of five millimètres."

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FIG. 10. A small portion of the original specimen of the telson of *Ceratiocaris Angelini*, from the left-hand side, as figured in Plate V. Fig. 1. Magnified 4 diameters.

II.—ON THE STRUCTURE OF *CLEISTOPORA* (*MICHELINIA*) *GEOMETRICA*, Edwards & Haime, sp.

By H. ALLEYNE NICHOLSON, M.D., D.Sc., F.G.S.,
Regius Professor of Natural History in the University of Aberdeen.

IN their great work upon the Palæozoic Corals (Polypiers Foss. des Terr. Pal. p. 252, pl. 17, figs. 3, 3a, 1851) Milne Edwards and Haime describe and figure, under the name of *Michelinia geometrica*, a remarkable little Coral from the Devonian rocks of France. By the kindness of Dr. Daniel Œhlert, of Laval, whose researches upon the stratigraphy and palæontology of the French Devonian rocks are well known, I have been enabled to examine some well-preserved examples of this interesting form, and have determined some new facts as to its internal structure. Investigation by means of thin sections has, in fact, shown that this Coral has in reality no close relationships with the genus *Michelinia*, but that its affinities are rather with *Protaræa*, E. & H. It differs, however, in important structural features from *Protaræa*, and appears to form the type of a new genus to which the name *Cleistopora* may be given.

Cleistopora geometrica, E. and H. sp. (Fig. 1, A), is a little discoid Coral, averaging from one and a half to two centimètres in diameter, from two to three millimètres in thickness in the middle, and usually attached parasitically to a Brachiopod or other foreign body. In some cases it appears to have been free. The short vertical corallites terminate in shallow hexagonal calices, which are mostly from five to six millimètres in diameter. The floor of each calice is formed by a flat or slightly convex surface, more or less clearly reticulated, which was regarded by Milne Edwards and Haime as being constituted by the highest of the "tabulæ," which they supposed to possess a strongly granulated exterior. Examination by means of thin sections (Fig. 1, C) shows, however, that "tabulæ" are entirely wanting, and that the whole visceral chamber, below the level of the calice, is occupied by a mass of reticulate or trabecular tissue, formed by irregularly anastomosing calcareous fibres.

This characteristic structure is shown equally well both by vertical and tangential sections (Fig. 1, C and D).

The walls of the corallites are thick, and when viewed in section under the microscope exhibit tolerably well the peculiar fibrous and subcrystalline structure which is seen in sections of many recent Corals. A true "primordial wall," such as is seen in many species of *Favosites*, does not seem to be present; but the junction between adjacent corallites is usually marked by an irregular dark line. The visceral cavities of contiguous tubes are placed in communication by irregular canals, which represent the "mural pores" of the *Favositidæ*. Septa are only represented feebly, by a number of obscure ridges or striæ.

FIG. 1. *Cleistopora geometrica*, Edw. & Haime, sp. A. Upper surface of a full-sized individual, of the natural size. B. A single calice enlarged. C. Vertical section of a specimen growing upon a Brachiopod, enlarged five times. D. Tangential section of the same specimen similarly enlarged.

From the above description it will be evident that *Cleistopora geometrica* E. & H. sp., is a Perforate Madreporarian, and that it is related to *Protaræa*, E. & H. In this latter genus, however, the visceral chambers of the corallites are very short, and are not filled up in their basal portion with the reticulated endothecal tissue, which is characteristic of the genus *Cleistopora*.

From the genus *Michelinia*, De Kon., *Cleistopora* is sufficiently separated, not only by the possession of the peculiar trabecular infilling of the lower part of the visceral chambers, but also by the total absence of tabulæ, while the "mural pores" are only represented by vermicular and tortuous tubes passing through the walls of the corallites. In the general aspect of the corallum, *Cleistopora geometrica* presents a considerable resemblance to the species of *Pleurodictyum*, Golf., from which, however, it is separated by characters similar to those which distinguish it from *Michelinia*.

Another distinctive character in *Pleurodictyum*—which I have recently determined by an examination of well-preserved specimens from the Corniferous Limestone of North America—is that in this genus the basal epitheeal plate is pierced by numerous well-marked foramina, formed by the external openings of the mural pores of the marginal corallites. It is probable that this character will be found to be constant in the genus *Pleurodictyum*, but I am not at present in a position to affirm that it is so.

The genus *Cleistopora*, Nich., may be defined as follows:—Corallum small, discoid, usually attached by its entire base to foreign bodies. Corallites short, prismatic, without tabulæ, and having the inferior portion of the visceral chamber completely filled up with loosely reticulate calcareous tissue. Septa represented by striæ only. Walls thick, traversed by minute irregular canals or pores.

The specimens of *Cleistopora geometrica*, E. & H. sp., which I have examined, were collected by Dr. Daniel Œhlert in the Devonian rocks of Viré, France.

III.—On the Occurrence of a *Ceratozamia* in the Tertiary Flora of Leoben in Styria.

By Dr. Constantin Baron von Ettingshausen, F.C.G.S.,
Professor of Botany, University of Graz, Austria.

MR. ADOLPH HOFFMANN has kindly sent me a large series of fossil plants from the Tertiary strata of Leoben containing a very rich fossil flora. On examining the latter, I discovered a fossil leaf, which I at once recognized as a *Cycad.*

Remains of that family of plants are extraordinarily rare in the Tertiary strata of Europe. They are limited almost entirely to the Eocene formation. The occurrence, therefore, of such a fossil in the Tertiary flora of Leoben, which belongs to the Miocene period, calls forth the greatest interest, and I shall not fail to give a preliminary notice on the subject to palæontologists.

The leaf-fossil resembles very much the leaf of *Ceratozamia*, a Mexican genus. It shows lanceolate-linear segments which are narrowed towards both ends and somewhat falciform. The borders are not toothed. The segments are 17 centimètres long and 17½ millimètres broad. The texture is firm, coriaceous. The nervation consists of 16 longitudinal nerves, being equally thin and undivided. They are rather prominent. The epidermis is well preserved and shows stomata which, relating to form and position, agree very closely with those of *Ceratozamia*.

Though I do not doubt that the fossil here described is a *Cycad*, it is well to take into consideration other possible determinations. In the first place there are the Coniferæ to be named to which the above fossil may be referred, especially the genus *Dammara*. But the leaves of the *Dammara*-species are simple, not divided, and relatively broader than the segments of the fossil in question, though structure and nervation do not differ in either. On account of the

longitudinal nerves being prominent, one might even be tempted, in determining this fossil, to consider the Gramineæ also. But the firm texture and the quality of the epidermis of the leaf do not admit of such a view.

I have named the species *Ceratozamia Hoffmanni.* The fossil leaf above described will be figured in my Memoir on the Tertiary Flora of Leoben.

IV.—Correlation of the Lincolnshire Pleistocene Deposits with those of the Midland Counties.

By R. M. Deeley, Esq.

THE Memoir of the Geological Survey on "The Geology of Part of East Lincolnshire," by A. J. Jukes-Browne, lately reviewed in the Geological Magazine, proves so interesting that I am tempted to compare the classification of the Glacial deposits which he has adopted with that I have proposed for the Midland Counties. There are also some features in the distribution and lithological characters of the Boulder Clays to which I should like to draw attention.

At the outset Mr. Jukes-Browne shows that there are in Lincolnshire two types of Boulder Clay occupying areas separated from each other by the Chalk Wolds. These two deposits, which he regards as having been formed at different stages of the Pleistocene period, are described as the "Older" and the "Newer Boulder Clay." The Older Boulder Clay, the Chalky Boulder Clay of Mr. Searles Wood, an intensely chalky deposit, is only found on the west side of Sheet 84 of the Ordnance Survey. The Newer deposits are brown or purple clays, which rise up from beneath the alluvium stretching along the coast. Both these deposits contain intercalated beds of sand or gravel. In a paper printed in the Quart. Journ. Geological Soc. vol. xli. p. 114, Mr. Jukes-Browne shows that the brown or purple clays, generally known as the Hessle and Purple Clays, frequently occupy interglacial valleys cut through the older Chalky Boulder Clay. In my own paper I found it most convenient to divide the Pleistocene period into three epochs, namely, Older, Middle, and Newer Pleistocene, the Great Chalky Boulder Clay and associated chalky gravels being relegated to the Middle Pleistocene division, an arrangement which might also be adopted for the similar deposits of Lincolnshire. As far as I am aware the only Older Pleistocene deposit in this county is the mass of Quartzose Sand on the hill near Gelston, north of Grantham. A careful search would doubtless reveal many other sections both of Boulder Clay and gravel. Too much reliance must not be placed on the colour of a deposit. Similarity of colour no doubt indicates that the materials forming the different deposits have been derived from similar rocks, but we must not be too ready to assume that it also indicates similarity of age. In the Midland Counties the adoption of such a test would lead to great confusion, for in this area the Older and Newer Pleistocene clays, having been generally formed by the breaking up of similar rocks, are somewhat similar in colour,

and yet they are separated from each other by the whole of the Middle Pleistocene series.

I do not mean to affirm that on this account the classification adopted by Mr. Jukes-Browne is incorrect, but it is possible that some of the brown and purple clays he describes belong to the Older and not to the Newer Pleistocene series. Such deposits would be difficult to recognize on the east side of the Chalk Wolds, as they would contain chalk and flint; but on the west the comparative scarcity or even total absence of these rocks should render their detection tolerably easy. In the Trent Basin, south and west of Newark, there are no signs of a submergence having occurred in Newer Pleistocene times. With the close of the Middle Pleistocene epoch marine conditions came to an end, and rivers commenced to re-excavate their valleys through the masses of Boulder Clay and sand which had been formed in them. Subaerial erosion also seems to have been active in Lincolnshire at the same time, for there the Newer Pleistocene Hessle and Purple Boulder Clays are found at low levels in valleys excavated subsequently to the formation of the Chalky Boulder Clay. This would make the Later Pennine Boulder Clay of the Midland Counties the equivalent of the Hessle and Purple Clays. In the Trent Basin, as I have remarked, the Later Pennine Boulder Clay shows no signs of aqueous action, whereas the equivalent low-level deposits in Lincolnshire seem to be of marine origin. If we admit the possibility of a Newer Pleistocene submergence of about 400 feet, such as Mr. Jukes-Browne requires, great difficulties present themselves; indeed, it would be necessary to assume great but local earth-movements without we imagine the whole of Central England to have been occupied by an ice-sheet, which displaced the water. The severity of the glacial conditions which really obtained in Newer Pleistocene times is as yet scarcely realized, yet at this age the cold was sufficiently severe to permanently freeze the ground in the South of England, and bring down great glaciers from the Cambrian and Cumbrian Mountains, which, spreading over Lancashire and Cheshire, eventually passed over the watershed into the Trent Basin. I am aware that this is disputed, many geologists regarding the striæ as being due to large icebergs grating along the bottom of a sea about 1200 feet deep; glaciers being with them at a discount. Now an iceberg is merely a fragment of a glacier, and therefore the larger the iceberg the larger the glacier. Consequently I prefer to make my glaciers larger than my icebergs, not *vice versa.*

During the Middle Pleistocene epoch the ice-flow seems to have passed from the north-east over the submerged Chalk Wolds, giving rise to the intensely Chalky Boulder-clay. At a still later stage, in Newer Pleistocene times, the ice came from the Pennine Hills or further west, and passing down the Trent Valley, pressed against the escarpment of the Middle Oolite. Through the gaps of the Humber and Witham Valleys the subglacial streams poured their sediment into the sea forming the Purple Clays. At one time it is probable that the ice actually passed out through the Witham and

Humber Valleys, or even over the Wolds as well, giving rise to the more chalky Hessle Clay. Before accepting a submergence of 400 feet, very strong proofs will have to be furnished, not only of the marine aspect of the high-level brown Boulder Clays, but also of their Newer Pleistocene age.

V.—Avalanches and Avalanche Blasts.—"Winter in the High Alps."

By John Addington Symonds, Esq.

THE following important and interesting notes on avalanches and the dangerous wind-blasts they cause, appeared in the *Pall Mall Gazette* for February 28th, 1888. As we do not remember to have seen the geological effects of these phenomena described in any detail in our numerous geological text-books, we believe Mr. Symonds' notes on the subject will be of much interest to readers of the Geological Magazine.

"*Feb.* 6.—We reckoned another foot of snow this morning. The Fluela Pass, which connects us with the Lower Engadine, was closed to traffic. Just before noon a man called Anton Broher, known among his comrades as "the Knave of Spades," because he had a bushy black beard, was swept away by an avalanche below Tschuggen, on the Fluela road, about three miles from Davos Platz. Eye-witnesses saw him carried by the blast of the avalanche, together with his horse and sledge, three hundred yards in the air across the mountain stream. The snow which followed buried him. He was subsequently dug out dead, with his horse dead, and the sledge beside him. The harness had been blown to ribbons in the air; for nothing could be found of it, except the head-piece on the horse's neck.

This violence of the wind which precedes an avalanche is well authenticated. A carter, whom I know, once told me that he was driving his sledge with two horses on the Albula Pass, when an avalanche fell upon the opposite side of the gorge. It did not catch him. But the blast carried him and his horses and the sledge at one swoop over into deep snow, whence they emerged with difficulty. Another man, who is well known to me, showed me a spot in the Schaufigg Valley (between Chur and the Streda Pass) where one of his female relatives had been caught by the wind of an avalanche. She was walking to church when this happened. The blast lifted her into the air, swept her from the road, and landed her at the top of a lofty pine, to which she clung with all the energy of desperation, The snow rushed under her, and left the pine standing. It must have been a trifling avalanche. Her friends, returning from church, saw her clutching for bare life upon the tree, and rescued her. Many such cases could be mentioned. A road-maker named Schorta this winter was blown in like manner into the air below Zernetz, and saved himself by grappling to a fir tree. I have been shown a place near Ems, in the Rhine Valley, not far from Chur, where a miller's house was carried some distance through the air by an

avalanche blast. Its inhabitants were all killed, except an old man above sixty and a child of two years. Again, I may mention that the tower of the monastery at Dissentis was on one occasion blown down by the same cause. In order to understand the force of the "Lavinen-Dunst," as this blast is called here, we must remember that hundreds of thousands of tons of snow are suddenly set in motion in narrow chasms. The air displaced before them acts upon objects in their way like breath blown into a pea-shooter.

Feb. 7.—It is still snowing. We reckon that there is an average depth of five feet in the valley. In the woods, and where it has drifted, the snow is of course much deeper. Four large avalanches fell to-day between Frauenkirch and Schmelzboden. One of them, in the Rutsch-tobel, below Monstein, caught some men working on the road. The man in advance, Caspar Valär, was blown across the stream and buried. The others managed to extricate themselves.

I have since then seen this avalanche. It covers about five acres in the valley, and has a depth in the deepest place of at least sixty feet. The trees on a hill above it have been mown down by the violence of the wind it carried [sucked after it?].

Feb. 9.—It is still snowing. The road between Davos and Wiesen is said to be impassable. The electric light is extinct in Davos Platz to-night, owing to an immense avalanche, which fell in the Dischma Thal and choked the water supply,

I must observe that when there is a considerable frost, the snow does not get easily into motion, and so there is less risk of avalanches. The greatest danger is when a thaw, with blustering warm wind, sets in while the snow is still falling. There are, roughly speaking, three sorts of avalanches. One is called "Staub Lavine," and descends when the snow is loose and recently fallen. It is attended with a whirlwind, which lifts the snow of a whole mountain side into the air and drives it onwards. It advances in a straight line, overwhelming every obstacle, and is by far the most formidable of the three sorts. The second is called "Grund Lavine." It falls generally in the spring-time, when the firm winter snow has been loosened by warm thawing breezes. The snow is not whirled into the air, but slips along the ground in enormous masses, gathering volume and momentum as it goes, and finding a way forward by its own weight. The third is called "Schnee-Rutsch," or snow-slip. It consists of a portion of snow detached upon a mountain slope, down which it slides gently, heaping itself gradually higher till it comes to rest on a level space. Small as the slip may be, it is very dangerous. The snow in motion catches the legs of a man, carries him off his feet, creeps up to his chest, and binds his arms to his side, being compressed by motion into a firm substance like hardening plaster of Paris. I once saw a coal cart with two horses and a man swept away by a very trifling slip of this sort. The man and one horse managed to keep their heads above it and were rescued. The other horse was stifled before he could be dug out.

Feb. 12.—Drove over the avalanches to Wiesen. At Glarus saw fifty-two men digging for the body of Caspar Valär. They have

been digging since the 7th, but in vain. His corpse will not be found until the spring. Meanwhile his widow is lying in a house which overlooks the place where her husband was overwhelmed. Avalanches have descended on both sides of the hill on which this homestead stands. The gorge which separates Davos from Wiesen, called the "Züge," or the "Paths of Avalanches," is a mere wilderness of snow shot down from either side."

That the weather this winter on the Continent has been exceptionally severe is still further shown by the following extracts from long and numerous newspaper reports:—

"Heavy snowfalls were again reported yesterday from the central districts of Northern Italy, where it is stated that in some places the snow is as much as ten feet deep. The Alpine troops with the Carabineers, under the direction and leadership of the authorities, have been working heroically in the task of rescuing the people of the small villages which have been buried in the masses of snow. By the latest accounts more than 200 bodies had been taken out. The hamlet of Trasquera, in Piedmont, at the foot of the Simplon, has been completely overwhelmed by an avalanche. In the Bini valley five persons have been killed by an avalanche.

"The strange coincidence of a violent thunderstorm and a heavy fall of snow occurring at the same time took place on Saturday morning in the Giant Mountains near Gorlitz, in Silesia.

"Two avalanches have fallen on the famous hospice of St. Bernard. The church has been almost entirely buried in snow."

(Communicated by C. Davies Sherborn, F.G.S.)

OF MEMOIRS.

I.—*Titanichthys pharao*, nov. gen. et nov. sp., AUS DER KREIDEFORMATION AEGYPTENS. By Prof. Dr. W. DAMES. Sitzungsb. Ges. naturf. Freunde Berlin, 1887, pp. 69-72, woodcuts.

SOME detached and partially broken teeth from the Lower Senonian of Egypt are described by Dr. Dames under the name of *Titanichthys pharao*. The specimens were obtained by Dr. Schweinfurth about 10 kilometres west of the Pyramids of Gizeh, and, when complete, measure 60 millim. in length. They are laterally-compressed teeth, with a very long root, rapidly tapering upwards, and marked by deep longitudinal furrows. The enamelled crown is relatively small, and of an unsymmetrical arrow-head shape, overhanging the summit of the root in front and behind, and thus giving the tooth a barbed character. The genus thus imperfectly indicated is regarded as new, and placed (with *Enchodus*) in the Trichiuridæ; if really undescribed, however, it will require another name, *Titanichthys* having been preoccupied by Newberry for a huge Placoderm (Trans. New York Acad. 1885).

II.—Die Gattung *Saurodon*, Hays. By Prof. Dr. W. Dames. *Ibid.* pp. 72—78.

DURING the investigation of the teeth of *Titanichthys*, Dr. Dames was led to study the semi-barbed teeth from the European Chalk originally referred by Agassiz to the American genus and species *Saurodon Leanus*, Hays. The result is an interesting *resumé* of the varied fate of the fossils in question at the hands of different palæontologists. Their resemblance to the teeth of the Trichiuridæ is discussed, and full references are given to the several descriptions and figures. It is unfortunate, however, that Hays' original memoir has not been consulted, nor yet the most important contributions of Leidy (Trans. Amer. Phil. Soc. vol. xi.) and E. T. Newton (Quart. Journ. Geol. Soc. vol. xxxiv.). The latter authors have shown that the European fossils are certainly not referable to *Saurocephalus* (of which *Saurodon* is a synonym), and those from the English Chalk are named *Cimolichthys levesiensis*. A. S. W.

REVIEWS.

I.—Geology, Chemical, Physical, and Stratigraphical. By Joseph Prestwich, M.A., F.R.S., F.G.S. In Two Volumes. Vol. II. Stratigraphical and Physical. Royal 8vo. pp. xxviii. and 606, with Geological Map of Europe, and numerous Illustrations. (Oxford, at the Clarendon Press, 1888.)

IF the number of geological papers published every year in various parts of the globe were taken as a measure of the increase of our knowledge, our sentiments on the subject might fitly find utterance in the word "Prodigious!" Nevertheless, while this great "talus heap of geological literature," as it has been rather irreverently termed, may at times produce a feeling of dismay and oppression, yet we may derive comfort from the thought that in due course of time the leading facts and the general results of this mass of information are tabulated and expounded in the larger Text-Books and Manuals.

Our advances in geological knowledge are then best gauged by such works as the one now before us, written as it is by one of our geological leaders, and whose object it is to exhibit the present state of the science. It might indeed be maintained that we are already well supplied with Manuals of Geology—Physical, Stratigraphical, and Palæontological; but it may also fairly be urged that one individual might devote his whole time to the literature past and present, and never learn a tithe of all that has been done in geology. Consequently the deficiencies of one work are compensated by others: and while we give honoured places on our bookshelves to the general Manuals of the older geologists—to Buckland, Bakewell, Trimmer, De la Beche, Phillips, Lyell, and Jukes, the value of whose works is now to a large extent historical; so alongside of Geikie, Green, Seeley, and Etheridge, we accord a hearty welcome to the two handsome volumes by the ex-Professor of Geology at Oxford.

Two years have elapsed since the publication of the first volume of Prof. Prestwich's work (see notice in GEOL. MAG. for 1886, p. 81), but the delay is amply explained by the amount of labour involved in the preparation of this second and larger volume—indeed the illustrations alone must have cost the author a very great deal of thought and attention. With regard to the aspect of the volume itself, we can only repeat what was said before, and speak in the highest terms of the clearness of the type, the excellence of the paper, and the beauty of the woodcuts and lithographic plates. In the matter of illustrations this second volume is even more profusely adorned than its predecessor. The large map of Europe, printed in colours and mounted on linen, which acts as a folding frontispiece, will in itself be a treasure to geologists. It is the work of Mr. W. Topley and Mr. J. G. Goodchild, and shows very clearly the distribution of the principal geological formations. Besides 256 woodcuts, a large number of which have been expressly engraved for this work, there are 16 lithographic plates showing characteristic fossils of different formations; they have been drawn on stone by Miss Gertrude Woodward, and we may observe that we have seldom seen in any geological work illustrations which for beauty and accuracy are equal to these. The woodcuts include pictorial views of scenery as well as groups of fossils, and sections to show the structure of various districts; and there is also a map showing the probable extent of land covered by ice and snow during the Glacial Period. It is no exaggeration then to state that this is the best printed and best illustrated geological text-book that has been produced in this country.

The former volume dealt with rocks, sedimentary and eruptive, and their method of formation; it treated of ice and ice-action, coral-islands, earthquakes and volcanoes, underground water and springs, metalliferous deposits, and metamorphism.

The present work is mainly devoted to the geological history of the stratified rocks. Commencing with a brief account of the early conditions of the earth's crust, the author gives a condensed account of the various formations in ascending order, pointing out their chief physical features, the forms of life represented at each great period, and the distribution of the rocks over the surface of the globe.

In such a comprehensive survey it is impossible to enter into much detail respecting the minor divisions of the rocks, and their varying lithological characters, but strict impartiality so to speak in dealing with different formations is apt to detract from originality, and may well be pardoned. Nevertheless we feel that some formations have received but scant courtesy, and this remark refers especially to the Devonian rocks and Old Red Sandstone, and to the Carboniferous Limestone Series. On the other hand, the Corallian rocks and some of the Tertiary strata are treated in considerable detail. But while the stratigraphical features of the rocks are for the most part dealt with in a broad and general way, their palæontology is very fully discussed. The leading genera and many of the species are enumerated, while palæontological summaries are given of the life of the larger divisions of the strata, showing the

period of incoming of the different classes, and the orders and genera peculiar to the Palæozoic, Mesozoic, and Kainozoic eras. In the various tables which he has prepared the author acknowledges his indebtedness to the elaborate work on Stratigraphical Geology and Palæontology issued in 1885 by Mr. Etheridge.

Of great value to students will be the excellent accounts of the foreign equivalents of our strata, one of the most important features in this work. Not only are the sedimentary rocks in different parts of Europe described, together with their chief palæontological features, but the rocks so far as they have been determined in other parts of the globe are likewise mentioned: so that with the aid of the geological map of Europe prefixed to this volume, and the smaller geological map of the world prefixed to the former volume, the student can follow out the geographical distribution of the main divisions of the strata and make himself acquainted with the principal facts in their life-history. Several Tables of Strata are given in the volume before us. Table I. shows the Sedimentary Strata in England and their Correlation with some of the principal Continental Groups. Then follow Tables of the formations in India, North America, Australia, New Zealand, and South Africa; these include lists of the characteristic fossil genera of the principal divisions, and a column showing the probable age of the formations compared with the general "time-divisions" in Europe.

It appears likely that the Table of English formations was printed off some time before the rest of the work was in type, for we notice several discrepancies between the grouping adopted in the table and that in the text. Thus in the former the Folkestone Beds are placed with the Gault, and in the latter they are grouped with the Lower Greensand. The Lenham Sands are doubtfully placed with the Miocene in the Table, and later on they are provisionally placed with the Pliocene; the Bure Valley Crag is classed as pre-Glacial in the Table, while in the text further on it is grouped with the Pliocene as part of the Norwich Crag. Moreover, in this Table the Recent deposits are not given so much prominence as they are in Table II., and curiously enough they are separated from the Quaternary Period. The term Kainozoic should be employed as a comprehensive term to embrace both Tertiary and Quaternary.

The terms pre-Glacial and post-Glacial are still used by Prof. Prestwich, although vague terms of this character are much to be deprecated, as they are liable to be used in different senses by different writers, and they have thus no definite chronological value. Noteworthy instances of this have occurred at recent meetings of the Geological Society.

The term Oligocene is adopted, the Permian is grouped with the Palæozoic, while the Silurian is employed in the old Murchisonian sense, although the term Ordovician, now very largely used for the "Lower Silurian" strata, is mentioned in a footnote. On the whole, however, we are glad to find that the old familiar names of formations are used by the author.

If the labours of original workers are more or less hidden in

the "talus" before mentioned, so we naturally look for a due record and acknowledgment of them by those who have sifted out and sorted the facts; and the long list of authorities referred to or quoted by Prof. Prestwich will testify to his laborious research. Even then we miss some well-known names, but when we remember that the "talus" includes 43 volumes of the Quarterly Journal, 24 Geological Magazines, 41 volumes of the Palæontographical Society, not to mention countless other Journals, Transactions and Proceedings at home and abroad, some omissions are not surprising, for even the "Geological Record" has failed to keep pace with these publications.[1] And among the long list of papers there are many whose interest is purely local, and others that tend but little to advance our general knowledge. It might be observed, however, that authors would facilitate the study of the literature were each one to add a summary of his views and conclusions at the end of his papers.

Geology is indebted, however, not only to those who have written papers on various subjects: it is also largely indebted to many individuals who have never committed their views to print. This is particularly the case with our local geologists who have accumulated large collections of fossils, and who are ever ready to communicate their knowledge to those who come in search of it.

In reviewing the present work we naturally turn to portions which deal with debateable subjects, but as a rule we do not find special verdicts on vexed stratigraphical questions, even when we might expect them, the reader being left to form his own judgment; the most original portions of the book are those which deal with questions in physical geology.

In briefly treating of the Archæan rocks, the author observes that "although great heat and pressure might effect radical changes in early sediments when covered up by thick masses of newer rocks,—as are the gneissic rocks of North-Western Scotland, or the felsitic rocks of Wales, by overlying Cambrian and Silurian strata,—they would not affect Archæan areas such as those of North America and Scandinavia, which we have reason to suppose have never been covered, or only to a very slight extent, by newer strata, and which, nevertheless, exhibit either the effects of intense metamorphism, or else the effects of hydro-thermal conditions originally different." These views will no doubt interest students of these ancient rocks; we may also note that the organic nature of *Eozoon* is practically accepted by the author.

In his account of the Cambrian and Silurian rocks some mention of Barrande's 'Colonies' might have been given, and also of Mr. Marr's modified interpretation of them.

The author considers that, during the Coal-period, the atmosphere was more dense, and more charged with moisture and carbonic acid, and he is led "to conclude that the coal-growth was in all probability one of extreme rapidity, and consisted of woods and plants contain-

[1] The Geological Record for 1879 was published in 1887.

ing a much larger proportion of carbon than any existing forest vegetation." With regard to the excess of carbonic acid gas, Mr. Carruthers has expressed an adverse opinion, and experiments made on living plants have shown that they are liable to be poisoned, like animals, by an excess of the gas.[1]

On the question of the duration of Coal, Prof. Prestwich adheres to the opinion expressed by the Royal Commission of 1871, that allowing for the rapidly increasing rate of consumption, the supply may last for about 400 years. It is interesting to learn that a coal-pit at Ashton Moss in the Manchester Coal-field has recently been sunk to the great depth of 2850 feet, and another pit in Belgium to 3411 feet.

In dealing with the Permian and Triassic rocks the author refers to the great earth-movements that took place before and between these periods, but it is not perhaps sufficiently pointed out that in this country the greatest physical break is at the base of the Permian. With regard to the Trias, the central division known on the Continent as the Muschelkalk "is wanting, unless it be represented by the 'Water-stones.'" Here some allusion might have been made to the sequence of Red Rocks in Devonshire, and to Mr. Ussher's subdivisions of Upper, Middle, and Lower Trias.

The author devotes some space to the subjects of rock-salt and gypsum, and illustrates his remarks with an account of a boring in Haute-Saône. The origin of the colour of the red rocks and the causes of the rarity of fossils are also discussed.

The Rhætic Beds are grouped with the Trias, but the White Lias is divorced from them and placed with the "Infra-Lias." This is not a happy arrangement, especially too when the White Lias and Sutton Stone are associated and their fossils intermingled. The latter deposit was grouped by Charles Moore in the Zone of *Ammonites angulatus*, and although this is a debateable subject, yet in the tabular arrangement given by Prof. Prestwich (p. 175) we have the "White Lias and Sutton Stone Beds" with *A. angulatus*, *Lima gigantea*, etc., placed below the zone of *Ammonites planorbis*. The White Lias is distinguished from the Lower Lias by the absence of Cephalopoda, while it contains *Cardium Rhaticum*, *Pecten Valoniensis*, *Lima præcursor*, and species of *Pleurophorus*, *Axinus*, etc., that link it with the *Avicula-contorta* shales. Moreover, at the localities mentioned, where the surface of the Rhætic beds is said to be eroded, it is above the *White Lias* that this "slight break" locally occurs.

A tabular list of the Lias zones is given (pp. 182, 183), including those of *A. opalinus* and *A. Jurensis*, the Midford Sands being taken in with the Lias, although regarded as passage-beds between that formation and the Inferior Oolite. In this table *A. capricornus* should come below *A. margaritatus*. We are glad to see that Prof. Prestwich prefers the old generic name of *Ammonites* to the many subgeneric names introduced by some palæontologists. A full general account of the organic remains of the Lias is given.

The various divisions of the Oolites are treated mainly from a

[1] See Geol. Mag. 1869, p. 300, 1871, p. 497.

West of England point of view, but there are short accounts of the beds in the Midland counties, Lincolnshire and Yorkshire.[1]

Passing on to the Cretaceous chapters, we miss a reference to Mr. Meyer's observations on the "Punfield Formation," for these to a certain extent tended to destroy its individuality. The various divisions of the Wealden and Lower Greensand, however, are briefly noticed, and the more marked physical changes are pointed out. The unconformity and overlap of the Lower Greensand where it rests on the Jurassic rocks in Wiltshire and other parts of the country is in reality more pronounced than the word '*slight*' seems to indicate.

With regard to the Greensand of Blackdown much information has been given in papers by the Rev. W. Downes, while Mr. Meyer relinquished the opinion that any part of the formation was synchronous with the Upper Neocomian (Quart. Journ. Geol. Soc. vol. xli. p. 27).

The account of the Chalk and its origin, together with that of the flints, will be read with interest. Prof. Prestwich is of opinion "that during the sedimentation of the Upper Gault, Greensand, and Lower Chalk, silica, held in solution by alkalies or carbonic acid, was introduced in exceptional quantities into the Cretaceous seas by rivers and springs, and that it there underwent decomposition in presence of some of the sea-salts." We must, however, refer our readers to the work itself for the amplification of these views, the author concluding that "it is to the presence of silica in the peculiar condition known as soluble silica that the formation of flints is due."

The Tertiary strata call for no especial remark. On this subject, indeed, our knowledge is most largely due to Prof. Prestwich himself. The Lower Bagshot Sands, as noted in a recent paper by the author, are grouped with the Lower Eocene on account of their intimate connection with the London Clay. The Bovey Tracey Beds are discussed with the Oligocene Beds, the author remarking that the evidence brought forward by Mr. J. S. Gardner to place them in the Eocene division is "by no means conclusive."

In the Pliocene chapter the Lenham and St. Erth Beds are duly noticed, while the Coralline Crag is described under the name of "White Crag." The Cromer Forest-bed is, however, included in the "Westleton Series," and mentioned among the Pre-Glacial beds of the Quaternary Period. The Glacial beds and associated phenomena are described at some length, and the author concludes "that after the first extreme glaciation, and the formation of the Lower Boulder-clay or Till, a great depression ensued, by which Central England, Wales and Ireland, were submerged to the extent of 1500 to 2000 feet. This led apparently for a time to the inset of warm marine currents, and the introduction of a more southern marine fauna; but, as the land again rose, and the warmer currents were diverted or stayed, colder conditions resumed, and arctic

[1] We should mention that the references to figs. 1 and 2, and 5 and 6 on plate vi.; those to 4 and 5 on plate vii.; and again those to 7 and 8 on plate x. are unfortunately transposed.

Mollusca returned for a time to the coasts of Scotland." He adds that "the phenomena, as a whole, go to show that the glaciation of Great Britain was not due to a great polar ice-cap, but was of local and independent origin." With respect to the account of the supposed great thickness of Boulder-clay at Boston (p. 446), we should mention that a different interpretation of the section was given by Mr. Jukes-Browne (Quart. Journ. Geol. Soc. vol. xxxv. p. 418).

In the preface to the former volume the author announced himself as to a certain extent a non-conformist in Geology, inasmuch as he had been led to believe that in the long course of geological history, the physical forces underwent constant variation in degree and intensity of action. While we believe that strictly uniformitarian views are held by few if any geologists at the present day, we are quite ready to admit that the views put forth by Prof. Prestwich will exercise a wholesome influence on geological thought, although certain of the opinions to which we have drawn attention may possibly be regarded as somewhat extreme and "out of date." In the concluding chapters of this second volume the author discusses some of the theoretical questions on the primitive state of the earth, and the condition of its crust. Here, too, he expresses his disagreement with the notion of "the lengthened permanence, as a whole, of the ocean-troughs."

Space will prevent our mentioning many other subjects of interest discussed in this volume, but we may confidently commend it to the advanced student, the specialist, and the professor, indeed to all who seek to become acquainted with modern achievements in geological science; for all inquirers will find some matters of particular interest to them, obscure topics on which a new light is thrown, or theoretical subjects illuminated in a way differing from that usually held to be orthodox.

II.—Prof. A. Gaudry on the Permian Reptilia and Amphibia of France. ("L'Actinodon," *Nouv. Archiv. Mus. d. Hist. Nat.* vol. x. pp. 1-32, pls. i.-iii. (1887). "Les Vertébrés Fossiles des Environs d'Autun," *Mem. Soc. Hist. Nat. d'Autun*, vol. i. pp. 1-90, pls. i.-xi. (1888).

THE petroleum works in the Permian shales of Igornay and Autun in the department of Saone-et-Loire of Central France have brought to light a number of vertebrate remains which now enrich the collection of the Paris Museum, and throw much light on the fauna of this early epoch. These remains, as we learn from Prof. Gaudry's memoirs, have been collected and sent to the Museum through the exertions of MM. Roche and Bayle, and other gentlemen connected with the works; to whom all students of this branch of palæontology are deeply indebted. And it is with regret we learn that the all-pervading American competition has caused the closing of these works for the present. M. Gaudry records seven species of Reptiles and Amphibians, referred to six genera, and seven species of Fishes, arranged under five generic headings, from these deposits.

In the 4to. memoir on *Actinodon* cited above Prof. Gaudry gives us a full description of the magnificent series of remains of this interesting Labyrinthodont, of which preliminary notices have been published in previous works. The most important of these remains is the nearly entire skeleton exceeding two feet in length, of which a full-sized representation of the dorsal aspect is represented in plate i. of this memoir. In this skeleton the skull, vertebral column, pelvic girdle, and limbs are beautifully preserved; and we are glad to be able to inform our readers that Professor Gaudry has kindly presented a cast of this fine specimen to the British Museum. Other specimens exhibit the three thoracic plates on the

FIG. 1. Ventral aspect of the thoracic buckler of *Actinodon Frossardi*. Reduced, *ent.* interclavicle; *ep.* clavicles; *s.cl.* supraclavicle; *o.* scapula.

ventral aspect of the body (Fig. 1), which are generally correlated with the clavicles and interclavicle, and which present a strong general resemblance to the probably homologous ento- and epiplastra of the Chelonia; while other examples exhibit the dermal scutes covering the greater portion of the ventral aspect of the body. *Actinodon* belongs to a group of Labyrinthodonts confined in Europe to the Carboniferous and Permian epochs, and characterized by the so-called 'rhachitomous' structure of the vertebræ (Fig. 2). In such vertebræ the body, or centrum, is imperfectly ossified, and consists of two lateral elements termed the pleurocentra (*pl. c.*), and a median, horse-shoe-like, piece known as the intercentrum or hypocentrum (*i.c.*). Considerable discussion has taken place as to the precise homology of these elements, into which it would be out of place to enter here; but it may be observed that the general balance of opinion is in favour of regarding the hypocentra as the representatives of the centrum proper, while the intercentrum corresponds to the intervertebral wedge-bones of *Sphenodon*, and is therefore a true intercentral element. M. Gaudry, however, does not quite agree with these conclusions.

In Europe this group includes, among others, *Archegosaurus*, which is both Carboniferous and Permian, *Euchirosaurus* (Fig. 2) of the French Permian, *Cochleosaurus* from the corresponding beds of Bohemia, and *Platyops* from those of Russia. In Africa it is represented by *Rhytidosteus* of the Karoo system; in India by *Gondwanosaurus* of the Bijori beds of the Gondwanas; while the

preoccupied name *Platyceps* has been recently applied to an allied form from approximately equivalent beds in New South Wales. In the New World the strata in North America commonly termed Permian have also yielded a number of kindred forms, such as *Trimerorhachis*, *Eryops*, *Zatrachys*, *Cricotus*, etc. Whether these numerous forms should be referred to one or more families, or whether several of the genera will subsequently have to be united, is a matter of but little moment: their interest lying in the evidence they afford that at an early epoch of the world's history the terrestrial vertebrate life over at least a large part of the surface of the globe presented the same general *facies*. To assume, however, that these different forms existed at precisely the same absolute date in widely distant regions is clearly illogical. But if we have only

FIG. 2. Left lateral and posterior views of a vertebra of *Euchirosaurus Rochei*. nat. size. *n.* neural spine, with lateral expansions *al.*; *s.* suture between spine and arch; *za.* *zp.* anterior and posterior zygapophyses; *d.* transverse process; *c.* costal articulation; *pl.c.* pleurocentrum; *i.c.* intercentrum; *c.r.* neural canal; *not.* notochordal vacuity.

to reckon by the evidence of land deposits, and are careful to use the term *homotaxial equivalency* in its proper original sense (*i.e.* as essentially implying the absence of absolute synchronism), then it may be convenient to provisionally regard the deposits in which most of these Labyrinthodonts occur as of Permian, or perhaps in some cases of Lower Triassic, age. It may, however, happen that, to use Professor Huxley's graphic simile, we shall eventually be able to correct our terrestrial clock by our marine clock, when we may find that the former has lagged behind, so that our European

Permian land fauna in distant regions co-existed with an Upper Triassic marine fauna. In such an eventuality we should, of course, have to take the marine clock as the standard time-keeper.

The second memoir quoted at the head of this notice is mainly a reprint of separate articles published by the author in the Bull. Soc. Géol. France, and in the second part of his "Enchaînements du Monde Animal" (1883); and is illustrated both by woodcuts and plates. It forms the first part of a new serial commenced by the Natural History Society of Autun, which is to be congratulated on such an excellent beginning. A reduced plate is given of the skeleton of *Actinodon* already noticed, together with one of a beautifully preserved portion of the vertebral column of *Archegosaurus*; while other plates are devoted to *Haptodus*, *Euchirosaurus*, *Protriton*, *Pleuroneura*, etc. Among the Labyrinthodont forms illustrated by

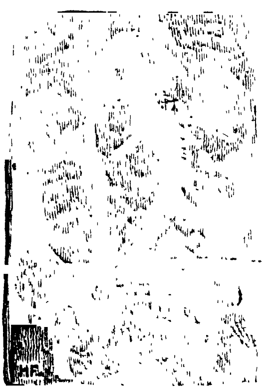


FIG. 3. Slab showing the skeleton of a young individual of *Protriton petrolei*. Nat. size.

FIG. 4. Anterior aspect of the imperfect left humerus of *Stereorhachis dominans*. Nat. size.

the woodcuts, we may especially call attention to the remarkable lateral expansion of the summits of the neural spines of the vertebræ of *Euchirosaurus*, of which, by the courtesy of Prof. Gaudry, we are enabled to reproduce the illustration in Fig. 2. The probable identity of the French *Protriton* (Fig. 3) with the Bohemian *Branchiosaurus* has been already noticed in a review published by the present writer in the previous volume of this Journal. The true Reptiles found in the Autun deposits comprise *Haptodus* and *Stereorhachis*. The former is known by a considerable portion of the skeleton, although unfortunately in a much dislocated and unsatisfactory condition. Prof. Gaudry suggests that this form may be allied to

the Thuringian *Proterosaurus*, although the teeth are not implanted in distinct sockets, as was thought to be the case with the latter. Since, however, Prof. Seeley has recently shown that the latter supposition is incorrect, the alleged difference is non-existent; and the skull of *Haptodus* certainly appears to present a striking general resemblance to that of the Thuringian genus, as far as its crushed condition admits of comparison. The second genus, *Stereorhachis*, is described upon the evidence of part of the upper jaw, vertebræ, and the humerus (Fig. 4). Prof. Gaudry suggests affinity with Prof. Cope's North American genus, *Clepsydrops*, which is found in the same beds as the *Actinodon*-like Labyrinthodonts. The structure of the humerus, with its characteristic entepicondylar foramen, clearly shows that this form is a member of the suborder Theriodontia (Pelecosauria), and the probability of its belonging to the *Clepsydropidæ* appears very strong.

We may conclude not only by complimenting the learned Professor of Palæontology in the Paris Museum on the issue of these two memoirs, but with the hope that the incessant revolutions in commerce will ere long render it practicable to work the Autun oil-shales at a profit. R. L.

III.—The Solomon Islands, their Geology, etc., by H. B. Guppy, M.B., F.G.S., late Surgeon R.N. Pp. 152, with Maps and Two Plates. (Swan Sonnenschein, Lowrey & Co., 1887.)

THIS is the companion volume of a work entitled "The Solomon Islands and their Natives," which was reviewed in "Nature," Dec. 29, 1887. In his larger work the author dwelt on the ethnology, climate, natural history, botany, etc., of these Islands, and in the one now under consideration, which was published simultaneously, he deals with their geological structure and general physical features. He states in the preface that the chief value of his observations lies in the fact that his collections of the calcareous rocks and of the other recent deposits were examined by Dr. John Murray in the light of the results obtained by him from the examination of the deep-sea deposits procured by the "Challenger" and other expeditions, and also in the circumstance that the characters of the volcanic rocks were determined by Prof. Judd and Mr. T. Davies with the aid of numerous microscopic sections. Mr. H. B. Brady has likewise been engaged in examining some of the Foraminifera. A type collection of the calcareous rocks and other deposits has been placed in the Jermyn Street Museum, and the volcanic rocks are in the British Museum.

Some of the larger islands, like St. Christoval, are mainly composed of much altered and highly crystalline volcanic rocks, such as (in the order of their frequency) dolerites, diabases, diorites, gabbros, serpentines, saussuritic felspar rock, etc. It is most probable that the greater number of the seven large islands of the group are mainly composed of these ancient and highly altered volcanic rocks. The Island of Bougainville, however, would

appear to be of more recent volcanic origin. It seems to be formed of a linear series of lofty mountain cones, one of which at least is active at the present day. The smaller islands of volcanic constitution are either mixtures of modern rocks with more ancient and often highly crystalline rocks, or they are composed almost entirely of recently erupted material. In the latter case the islands preserve the volcanic profile, possess craters, and sometimes exhibit signs of latent activity. Pages 8–62 are devoted to the details of these volcanic islands.

That an enormous amount of denudation has affected the Solomon Islands is evident from the laying bare of the deep-seated plutonic rocks before mentioned; and it is also equally certain that this is an area of elevation, by no means remote in time, through a vertical range of some thousands of feet. This is abundantly shown by the various muds and oozes of deep-sea type which now constitute a notable proportion of the land above sea-level—a class of deposit possessing considerable interest for geologists, whilst to those who have been engaged in testing the nature of the ocean floor such rocks afford an opportunity of a comparison of great value. Hitherto there has been little chance of studying the consolidated oceanic muds, since it is pretty well understood by this time that the ordinary formations of continents and continental islands, such as our own, have nothing in common with the oceanic muds and oozes now in course of deposition. It is just possible that the Chalk may be an exception to this rule, but at any rate we have quite enough controversial matter before us without troubling ourselves with this question. The so-called "chalk" of New Ireland is regarded by Mr. Brady as a deep-sea deposit of comparatively recent age, which was probably formed in depths of not less than from 1500 to 2000 fathoms. Then again there is the well-known Suva deposit, or so-called "soapstone" of the Fiji Islands, which has been the subject of a recent communication by Mr. Brady to the Geological Society. Thus glimpses have from time to time been obtained of the nature of the deep-sea deposits, when elevated into dry land, from more than one quarter, and we are therefore prepared to read Mr. Guppy's account of the recent calcareous formations of the Solomon Islands with a considerable amount of interest, not to say of curiosity.

The recent rocks, he says, may be arranged into several groups, commencing with the coral limestone and ending with the deeper deposits. The *first group* includes the coral limestones properly so called, which are mainly composed of the massive corals in different stages of fossilization. The interstices are filled by coral débris, molluscan shells, and the remains of the numerous organisms that live upon the reefs.

The *second group* includes those coral limestones which have the composition of the coral muds and sands that were found by the "Challenger" expedition to be at present forming near coral islands and along shores fringed by coral reefs. They are derived chiefly from the disintegration of the neighbouring reefs, but they receive

large additions from the shells and skeletons of pelagic organisms, as well as from those of animals living at the bottom. Three principal varieties are indicated in this group, which includes the majority of the so-called coral limestones found in the Solomon Islands. The non-calcareous matter, which is small in amount, consists of the common volcanic minerals, and a few glassy fragments, etc. The chalky coral limestones constitute a section of this group; and the consolidated calcareous ooze of the channels, which forms compact fawn-coloured limestones of homogeneous texture, also is referred to this group.

The *third group* comprises a still greater variety of rocks, corresponding in composition to the volcanic muds and pteropod oozes of the "Challenger." These are composed of the *débris* of volcanic rocks mixed with the shells of Foraminifera, Molluscs and many other calcareous organisms. Judging from the Foraminifera they may be regarded as of Post-Tertiary age.

The *fourth group* comprises the foraminiferal limestones, which are grey or yellowish-brown in colour, hard and compact in texture, and are chiefly made up of the tests of pelagic and bottom-living Foraminifera. They usually contain from 70 to 85 per cent. of carbonate of lime, and may be described as the consolidated foraminiferous oozes of the "Challenger" and other expeditions. An interesting description of a *Rhynchonella*-limestone and some valuable remarks relative to the beach sand-rock, which is generally regarded as in some way connected with the formation of oolite, follow, and then comes a detailed description of the several calcareous islands.

Dr. Guppy's descriptions of the calcareous formations of these islands afford, probably, the most complete account we have yet received of the rôle played by the deposits of the deep ocean in the formation of rock-masses; and, at the same time, it is difficult to conceive anything more interesting to geologists, who, if the charter of the Geological Society be accepted literally, are supposed to be desirous of investigating the mineral structure of the earth. This portion of the work is also, in the main free from controversial matter.

It would, however, have been impossible for Dr. Guppy to have ignored the question of the mode of formation of coral reefs, when engaged in the general physical investigation of the Solomon Islands. His conclusions on this point may be summarized as follows:—(1) That the upraised reef masses, whether atoll, barrier, or fringing reef, were formed in a region of elevation; (2) that such upraised reefs are of moderate thickness, their vertical measurement not usually exceeding the usual limit of the depth of the reef-coral zone; (3) that these upraised reef masses in the majority of islands rest on a partially consolidated deposit, which possesses the characters of the "volcanic muds" that were found during the "Challenger" expedition to be forming round volcanic islands; (4), that this deposit envelopes anciently submerged volcanic peaks.

Plans and sections are given in the two accompanying plates, and, if these are to be relied upon, the coral limestones are shown to exist

as little more than a facing or veneer upon the really bulky ooze deposits. Such an arrangement tallies far better with the developments of reef-building coral known to exist in our own islands than the more stupendous thicknesses assigned to reef rock under the subsidence hypothesis. Indeed the author claims that these excessive thicknesses may be altogether hypothetical in the majority of cases. It has, we believe, been no uncommon thing for geologists to overestimate the thickness of beds from various causes. As a familiar instance of this, we may cite the classical section of Assynt, where, according to the interpretation of Sir R. Murchison, a thickness of thousands of feet was assigned to the quartzite-limestone series of Ben More; whereas, if that celebrated geologist had taken the trouble to penetrate into the heart of the mountain, instead of inspecting its flanks alone, he would have found that this imposing and seemingly solid array was merely a casing over the great Archæan masses beneath—a trap, in fact, set by nature to catch those who are in the habit of taking a one-sided view of things.

Naval men of experience are evidently beginning to doubt the sufficiency of the subsidence theory to explain the production of barrier reefs and atolls. This has been made very plain by the notice on Coral Formations from the Hydrographer to the Admiralty which appeared in "Nature" (Feb. 23, 1888). At the same time we must guard ourselves against any unfair imputations which it may be sought to fasten upon the principal author of the subsidence theory, in view of its possible collapse.

That most judicial of all writers took into consideration the majority of the theories which had been advanced in his day, and if he ultimately decided in favour of the subsidence theory, it was more from lack of evidence than from any other cause. But the master is generally surpassed by the disciple in the implicitness of his faith. The latter, fascinated by an explanation which, in this case, has the merit of great ingenuity, and possessed by a natural unwillingness to admit that his wisdom is foolishness, views with suspicion anything likely to compromise his orthodoxy.

Such considerations may possibly help to account for the nervous reluctance of many geologists to accept any explanation of the origin of coral reefs unconnected with or adverse to the subsidence theory. It is perfectly true that Darwin had Dr. Murray's facts and inferences before him, and that he made no sign of change in his views (letter dated 1880, quoted by Mr. Mellard Reade in "Nature," Nov. 17, 1887), nor have we any absolute right to assume that even the remarkable physical history of the Solomon Islands would have induced him to modify them. But no matter how great may be the authority of any one individual, living or dead, if a series of facts, such as those recorded in the work before us, are plainly repugnant to the theory of subsidence in connection with the growth of reef-coral, it is the manifest duty of geologists especially to examine such facts without prejudice, and to be ready to modify their views in accordance with the ever-advancing tide of scientific knowledge.

W. H. H.

IV.—A Sketch of Geological History, being the Natural History of the Earth and of its Pre-Human Inhabitants. By Edward Hull, M.A., LL.D., F.R.S. 8vo. pp. 179. Coloured Sections. (London, 1887.)

In order that our Science may draw recruits from all types of minds and from all quarters, and that it may exercise due influence on other classes of research, it is necessary that its soundest and most advanced conclusions should occasionally be put before the world in an interesting fashion, in brief and popular books. In the days of Sedgwick and Murchison the science was accounted a hard-walking, hard-working, fighting science, suited for healthy bodies, keen eyes, and deep-thinking minds, while Lyell and Darwin made plain that work could be done by all, whether they had the opportunity of world-girdling travel or could only watch worms in a back garden. We recovered from an era of species-making and minute subdivisions when (though others shared in the researches) Sir A. Ramsay and Professor Hull gave to the reading public a chance of seeing the result of this work in the successive geographical phases through which our own and other areas have passed.

So when the latter author produces "A Sketch of Geological History," part of a series of works on Universal History, evidently intended to be read by a very large section of the public, we have high expectations that even this most abstruse branch of the science will be dressed in its most attractive garb, that we shall find arguments (at least indicated) as well as facts, that all but necessary technicalities will be shelved, and that we shall be presented with a comprehensive view of the inorganic condition of the surface of our planet, and of the organic evolution which took place upon it. One in need of such things turns to the work and alights on this passage:—"The Lamellibranchs were also exceedingly abundant, yielding 1319 species; the most abundant being the genera *Avicula, Gervillia, Gryphæa, Lima, Ostræa, Pecten, Pinna, Plicatula, Arca, Astarte, Cardium, Cypricardia, Gresslya, Leda, Modiola, Myacites, Mytilus, Opis, Pholadomya, Pleuromya,* and *Trigonia*; many of these genera survive in the seas of the present day." Will he close the book in despair? Let us see.

The work opens with a small division on the Consolidation and Cooling of the Globe, and the Plutonic Rocks. Perhaps this was inevitable, but surely the human mind would then hanker after some guiding principle to tell it how to digest the chaotic mass of "clay-slates, conglomerate, quartzite, and limestone," which it is shortly called upon to consume, into some form of nourishing mental pabulum. It needs to be shown in what forms the rocks themselves contain the evidence on which the old physical geography may be restored, but that this evidence is sometimes unattainable because the strata may have been removed by denudation or be covered by subsequent deposits. In the first case some help may be obtained if the strata are conformable by the evidence given by previous and subsequent deposits; if unconformable, by the very nature of the movements which produce the unconformity. In the second case

we are helped by facts gained by deep borings, by the facts of palæontological distribution, and by the nature of earth-movements of preceding periods.

Even if we pass over the extreme difficulty exhibited by the nature of the case in the Archæan and Lower Palæozoic ages, it is difficult to see why the author has said so very little about his favourite Devonian period, so little that even the customary "Position of Sea and Land during the Period" has been omitted. Turning again to the Carboniferous period, Englishmen reading an English book would have liked some reference, not only to the Atlantis, a summary of the arguments for which is given, but to the borders of the continent, whatever it was, on whose edges the deposits so important to our industries were made, and some of whose shore lines have been so well worked out in England. The notice of the wide spread of shells and plants in this period is interesting, but the untrained reader needs to be shown the bearing of this in the increased complexity of the barrier system which guides distribution, introduced by the development of earth-movement as time went on. The author again has been one of the chief to insist on great crust movements some time after the Carboniferous period; should he not have shown us that the development of the Pendle and London ridge, and other E. and W. ranges, and of the Pennine and other N. and S. ranges, must have had some influence on the geography of the succeeding Permian or, at latest, the Triassic periods? As we reach later times, the geography is better worked out, but even here we are not definitely told that while conformable strata furnish the history of submersion, unconformabilities are no less valuable as giving evidence of land surfaces, and, by telling us of movement and mountain building, show us in what direction to look for shore lines; nor do we think the term "conformable hiatus" has any very decided advantage over the older one of deceptive unconformity.

Side by side with rock history we are given an account of the fossils of each formation. The technical student has no need of such lists, and of what use can they be to the general reader? The author, rather late in the work, sets himself an example when he gives a partial sketch of the evolution in the ancestry of the Horse. Ought he not to have shown that the same can be done for some other Mammalia, and to have indicated, throughout the Tertiary period, a tendency to advance from generalized to specialized forms of life? The Dinosaurs and Birds have their proper share of attention in the Mesozoic rocks, but we cannot help thinking that a few words of explanation on the zoological position and affinities of the rest of the Reptiles, of the Amphibians, and the Fish would have been more useful than clouds of names; nor do we think that the bald statement that a species of *Ceratodus* survives in Australian rivers is enough to make of a most significant fact. Could not the author have helped the reader by giving him an inkling as to what a heterocercal tail really meant, and particularly in alluding to the embryonic fish types of the Devonian period? The possibility of an explanation of the sudden appearance of so many forms of life in the Cambrian period

ought hardly to have been passed by. Godwin-Austen's classical memoir might have suggested some points of importance in dealing with the Carboniferous rocks; there is not absolute unanimity amongst geologists as to the abyssal origin of the Chalk, or about the Miocene age of the Bovey lignites; while the height of Moel Tryfaen is generally given as 1360 and not 1170 feet.

The book suffers also from many misprints; there is hardly a fossil list without one; we often have œ for æ, and we meet with *artica, C. elaphas, Rhynconella, Anchyterium, Cristeltaria, Nautali, Archæopterix, Beleminites, E. liliiformiss*, etc. We cannot help closing the work with a feeling of disappointment that a capital opportunity has been missed of presenting to untechnical readers a readable and yet thorough and scientific "Sketch of Geological History."

V.—A Sketch of the Geology and Climate of Hertfordshire. By John Hopkinson, F.L.S., F.G.S., Treas. Geol. Assoc., V.P. Herts Nat. Hist. Soc. (Hertford, printed by Stephen Austin and Sons, 1887.)

THIS is an extract from the Introduction to the "Flora and Fauna of Hertfordshire," by the late R. Pryor, B.A., F.L.S., which now appears in a separate form as a small quarto of 52 pages, together with a coloured map of the county showing its river basins as adopted for the Botanical Districts. The interest is largely meteorological and botanical, but the whole structure is laid on a geological foundation. This part of the subject is illustrated by two maps, the first of which shows the superficial geology—Alluviun, Boulder Clay, Gravel and Sand chiefly Glacial, Brick-earth, Clay with flints and occasionally Brick-earth, Pebble Gravel, and lastly Eocene and Cretaceous. Although, of course, one or other of the two latter underlies the entire surface of the county, both are so largely masked by superficial or "drift" beds that the second, or agricultural, map is mainly influenced by the development of these superficial beds. Doubtless many of these facts are well known to students of the various Memoirs dealing with the London Basin, but Mr. Hopkinson has his own way of telling the story, and he contrives to put a considerable amount of useful matter before his reader within the limits of a very few pages. The chapter on Hydro-geology is especially interesting, and in view of the impending drought may well attract attention. The Botanical Districts would seem to coincide with the river systems. I. Drainage of the Ouse: 1 Cam, 2 Ivel. II. Drainage of the Thames: 3 Thame. 4 Colne, 5 Brent, 6 Lea. The first three are outside the London Basin and together constitute not more, perhaps, than one-eighth of the county.

W. H. H.

VI.—Annuaire Géologique Universel. Revue de Géologie et Paléontologie, dirigée par Dr. L. Carez pour la partie Géologique, et H. Douvillé pour la partie Paléontologique, avec le concours de nombreux Géologues Francais et Étrangers. Publié par le Dr. Dagincourt. Tome III. Paris, 1887. 8vo. 1[re] partie, Géologie, pp. xxvii. and 777; 2[e] partie, Paléontologie, pp. vii. and 235.

THIS third volume of the Annuaire Géologique Universel—a massive book of more than a thousand pages—has attained a development far in advance of its two predecessors. It contains a well-arranged Bibliography of the works published on the several different branches of geological science, and a comprehensive review of the geological and palæontological discoveries and work done and in progress in the different countries of the globe during the year 1886. This summary cannot fail to be of material assistance to all students of the science, and we hope it will have the wide circulation which it deserves.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Annual General Meeting, February 17, 1888.—Prof. J. W. Judd, F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the Library and Museum Committee for the year 1887. The Council stated that they had again to congratulate the Fellows upon the continued prosperity of the Society, although they had to state, with regret, that there was a diminution in the total number of Fellows. The number elected during the year was 46, and the total accession 53; but the losses by death, resignation, etc., amounted to 60, causing an actual decrease of 7 in the number of Fellows. Nevertheless from the large proportion of compounders and non-contributing Fellows deceased, the actual number of contributing Fellows was increased by 7. The balance-sheet showed receipts to the amount of £2760 15*s.* 9*d.*, and an expenditure of £2961 15*s.* 8*d.*, being an excess of expenditure of £200 19*s.* 11*d.*, caused by the expense incurred in the necessary repairs, painting, etc., of the house occupied by the Society; but notwithstanding this and the addition of £250 to the amount of the Society's funded property, the accounts showed a balance in the Society's favour. The Council's report further announced the awards of the various Medals and of the proceeds of the Donation Funds in the gift of the Society.

In presenting the Wollaston Gold Medal to Mr. Henry Benedict Medlicott, M.A., F.R.S., the President addressed him as follows:—

Mr. Medlicott,—The Council of this Society are not unmindful of the fact that many of our Fellows are engaged in the promotion of geological science in every part of a vast empire; in awarding to you the highest honour which is at their disposal, they are following a precedent which was established more than fifty years ago, by the presentation of the Wollaston Medal to Cautley and Falconer. In that great Indian dominion where those famous geologists carried on their important

researches, you commenced your labours as far back as the year 1854; and for more than a third of a century you have continued the almost incessant exertions which have led to very important additions to our knowledge, often obtained only at the price of severe hardships and at the risk of serious dangers. During the last eleven years you have occupied the important and responsible position of Director of the Indian Survey; and it is to your administrative ability in that position that we owe many of the valuable results obtained by that Survey in recent years; more especially are we indebted to you, and to our Secretary, Dr. Blanford, for that useful Compendium of Indian Geology which has now become indispensable to all students of our science. We feel it to be singularly appropriate that we are able to make this award to you just at the time that you return to your native country for the rest you have so well earned.

Mr. Medlicott replied:—Mr. President,—The award of the Wollaston Medal by the Geological Society is the most gratifying distinction that a Geologist can receive. It is only as a recognition of devotion to our Science that I can venture to accept so great an honour. My work has been chiefly in combination with others, and it gives me much consolation to think that my colleagues of the Geological Survey of India will share in this reward and will appreciate it.

In handing the Balance of the Proceeds of the Wollaston Donation Fund to Archibald Geikie, LL.D., F.R.S., for transmission to Mr. John Horne, F.G.S., the President addressed him as follows:—

Dr. Geikie,—The Council of the Geological Society being desirous of aiding Mr. John Horne in carrying on his important investigations in the Volcanic and Glacial geology of the northern part of our islands, have awarded to him the Wollaston Fund for the present year. Seeing that in their researches Messrs. Peach and Horne have been so constantly united, it was felt that in the recognition of their services to science they ought not to be divided; in the roll of honour containing the names of those who have received this award the name of Mr. Horne will appropriately follow that of his friend. In transmitting this award to our fellow-worker, will you express the hope that it may be of some service to him in enabling him to continue those studies which have already done so much towards elucidating the structure of the land of his birth?

Dr. Geikie, in reply, said:—Mr. President,—At the request of my friend and colleague, Mr. Horne, I have much pleasure in receiving for him the Wollaston Fund, and in conveying to the Society his cordial thanks for this mark of its appreciation. If anything could add to the pleasure with which he receives this prize, it would be the association with his friend and companion in geological labour, Mr. Peach, to which you have alluded. A member of the Geological Survey, placed in a distant and inaccessible region, has need of all the enthusiasm of his nature when he has to combat with great and difficult geological problems amid the lesser troubles of hard fare, poor lodging, and the absence of all those sympathies of human intercourse which so help us in our pursuits. To such a far off and, as it were, forsaken brother there can come no greater encouragement and stimulant than recognition of his labours from those who stand nearer to the central pulse of life in the country. Mr. Horne is so enthusiastic in the discharge of his official duties and in the cause of science as sometimes to risk his health by prolonged exposure to the inclemencies of the boisterous north. In this award he feels that his work, remote though its area may be, has not escaped the friendly notice of the Geological Society of London, and that it encourages him to give himself as heartily in the future as in the past to the advancement of the science to which we are all devoted.

The President then handed the Murchison Medal to Archibald Geikie, LL.D., F.G.S., for transmission to Prof. J. S. Newberry, M.D., F.M.G.S., and said:—

Dr. Geikie,—The Council of this Society in awarding the Murchison Medal to Dr. Newberry, desire to place on record their sense of the very high value of his geological researches in various parts of the United States. Dr. Newberry's studies have been pursued, during the last thirty years, in connexion with every branch of Geological Science. The maps and memoirs of the Geological Survey of Ohio afford the highest proofs of his skill as a stratigraphical geologist; numerous papers dealing with the phenomena of the Glacial Formations testify to the attention which he has

devoted to that important subject; while several of his memoirs treat of petrographical questions. In Palæontology Dr. Newberry has made many valuable contributions to our knowledge, especially in connexion with Fishes and Plants. Nor have the great problems of Geological Philosophy been neglected by our esteemed Foreign Member, who now occupies so important a post in connexion with one of the greatest educational institutions of his native country. When the Director-General of our own Geological Survey transmits to one of the pioneers of American Geology a medal founded by a father of British Geology, the action may be fairly held to typify the universal brotherhood of Science.

Dr. Geikie, in reply, said:—Mr. President,—On the part of Dr. Newberry I am commissioned to receive the Murchison Medal which has been awarded to him. Were my friend here himself, he would express, far more fittingly than I can, his gratification that the Geological Society of London has conferred this honour upon him. But there is one advantage perhaps in his absence, that we can freely speak of him and his work, regarding which he would himself wish to be silent; and it is of him and his work that the Fellows doubtless wish to hear.

It is now nearly forty years since he began his scientific career. During this long interval of constant and enthusiastic labour, as you have so well observed, there are few departments of Geology into which he has not entered, and where he has not left the impress of his clear insight, his singular mastery of detail, and his faculty of broad and luminous generalization. And yet this record of fruitful work has been achieved in the midst of continual demands on his time and thought made by professional and official duties—demands which for most men would have been enough to fill up a busy life. To geologists on this side of the Atlantic who know him only by published writings, there are more especially three lines of research with which his name is associated. It was he who in the expedition under Lieutenant Ives, eight-and-twenty years ago, first made known to the world the wonders of the Colorado River of the West, who recognized in that region monuments of the most stupendous denudation, and who by his clear and graphic descriptions inaugurated a new era in the discussion of the problem of land-sculpture. His researches on Fossil Plants have placed him in the very front rank of those who have made known to us the characters of the vegetation of former periods of the earth's history. As a fitting crown to these researches he will shortly publish a large monograph, with two hundred plates, descriptive of the fossil floras of North America. And, thirdly, his long and minute investigation of Fossil Fishes has enabled him to repeople the ancient waters of the North American continent with the abundant and often extraordinary types which characterized them. Another great monograph, with sixty plates, on this subject, is also in the press.

There seems to me something peculiarly appropriate in the award of the Murchison Medal to such a man. He is a geologist after Murchison's own heart—keen of eye, stout of limb, with a due sense of the value of detail, but with a breadth of vision that keeps detail in due subordination.

If I may be permitted, I would fain add a word of personal gratification that it has fallen to my lot to be intermediary on this interesting occasion between the Geological Society of London and one of the most distinguished men of science in the United States. The geologists of North America are drawn to us by stronger ties and closer sympathy than most of us are perhaps aware. They look on our Society as the parent of their own kindred associations. Our fathers in geology are also theirs. They wait for the advent of our Journal, and keep themselves far more fully conversant with what is done within these walls than most of us, I am afraid, do with their work. I confess that, for myself, I often feel ashamed and mortified that I can do so little to keep myself abreast of the rapid and astounding progress of our science on the other side of the ocean. We hardly realize and recognize as fully as we should the nature and bearing of the work of our brethren across the sea. So I hail this opportunity of holding out the right hand of fellowship, for I am certain that the geologists of the United States will feel that in doing honour to Dr. Newberry the Geological Society of London wishes at the same time to express its appreciation of American geologists and its best wishes for the advance of American geology.

In handing the Balance of the Proceeds of the Murchison Geological Fund to Henry Woodward, LL.D., F.R.S., for transmission to

to Mr. Edward Wilson, F.G.S., the President addressed him as follows:—

Dr. Woodward,—The Council of this Society, being desirous of marking their sense of the great value of Mr. Edward Wilson's geological investigations, have awarded to him the Balance of the Murchison Fund for the present year. Both at Nottingham and at Bristol Mr. Wilson has shown his ability as a careful observer and trustworthy exponent of the stratigraphy of the surrounding country; and it is our hope that this award may afford him both encouragement and assistance in continuing those important researches in fields of study where he has already laboured with such devotion and success.

Dr. Woodward, in reply, said:—Mr. President,—Mr. Edward Wilson is, I am happy to say, only one out of a large number of local geologists (many of whom are Fellows of this Society) all doing good work and all deserving of recognition, were it possible to extend to many more the same expression of approbation of their labours. Such assistance affords to them facilities for travel or for the acquisition of books for ·ng on their work.

These are only a few of the trivial advantages; but *the highest of all* is the sense of recognition which this Society's Award gives to such solitary workers, who are often without any local support or encouragement for their efforts. Mr. Edward Wilson's published work dates back to 1868, and is represented by more than 12 papers, dealing mostly with the Red Marls, Keuper and Bunter Beds, the Rhætic and the Lias, one of his latest papers being on the Liassic Gasteropoda with descriptions and figures of 14 species.

Dr. Woodward further read the following communication from Mr. Wilson:— "Will you kindly convey to the President and Council my grateful sense of the honour which they have conferred upon me? At the same time would you please express my regret at not being able to be present on this occasion?

"Notwithstanding the progress which has been made in our knowledge of the late Palæozoic and early Secondary Rocks, since the illustrious Murchison established his Permian system, now nearly fifty years ago, a great deal remains to be accomplished in this special department of British geology. In several districts the true ages of the "Red Rocks"—whether Permian, or Trias, or Carboniferous, or even Old Red Sandstone—have yet to be determined. Of the many other interesting matters relating to these rocks which require further elucidation, one of the most important perhaps is the question of the extension of the older rocks, and in particular of productive Coal-measures, beneath the newer formations. In the above field of Geology, then, there is scope for plenty of good work in the future, and it is in this field that my highest ambition would be to contribute some useful result."

In presenting the Lyell Medal to Prof. H. Alleyne Nicholson, M.D., F.G.S., the President addressed him as follows:—

Prof. Nicholson,—The Lyell Medal has been awarded to you as a mark of appreciation of your valuable researches among the older Palæozoic rocks, both in the Old and New World, and of your continued and patient investigations into the organization of some of the obscurer forms of life which abounded at the period of the deposition of those rocks. Your researches among the Graptolitidæ, the Stromatoporidæ, the Monticuliporidæ, and the Tabulate Corals have given you a high place among palæontologists; while the difficulties which surround such studies as those you have undertaken are so great that geologists may well feel admiration for the courage and perseverance which you have shown in steadily devoting yourself to the study of such seemingly unpromising materials. The bequest of Lyell could certainly not be more appropriately bestowed than in recognition of labours like your own, which have been especially directed to a comparison of the fossil faunas of Britain and North America.

Prof. Nicholson, in reply, said:—Mr. President,—It would not be easy for me to adequately express my grateful sense of the very high honour which has been conferred upon me by the Council and Fellows of the Society in awarding to me the Lyell Medal. In common with all British workers, I regard the Geological Society of London as the supreme head and source of honour in matters connected with Geology and Palæontology. Under any circumstances, therefore, I should have deeply valued the distinction which I have to-day received, the more so that it is

associated with the name of one whose memory will ever be honoured by students of Geological science. To a very special degree, however, and in a very special sense—a sense only to be fully comprehended by those similarly placed—is there a gratification and a stimulus in such an award to a worker so unfortunately isolated by his geographical position as it is my lot to be, and with such limited opportunities of coming in contact with his fellow-workers. The pleasure I have felt has been enhanced by the friendly words of encouragement and approbation in which you, Mr. President, have seen fit to speak of my past work. If I cannot feel that I have sufficiently deserved, by anything I have yet been able to accomplish, the high honour I have to-day received, I can assure the Council and Fellows that I shall do what in me lies to make myself more fully worthy of it in the future.

The President then presented one moiety of the Balance of the Proceeds of the Lyell Geological Fund to Mr. Arthur Humphreys Foord, F.G.S., and addressed him in the following terms:—

Mr. Foord,—Your skill with the microscope and pencil have stood you in good stead in investigating and illustrating the minute structures of many wonderful fossils from the older rock-masses of our globe. To our knowledge of some of these remarkable organisms, which alike from their aberrant characters and from the very remote period at which they lived, must ever have the greatest fascination both for Geologists and Biologists, you have made some very valuable contributions; and the Council of this Society trust that an Award from the Lyell Fund will serve as a stimulus and aid to you in carrying on these and kindred researches.

Mr. Foord, in reply, said:—Mr. President,—I beg to return my warmest thanks to the Council of the Geological Society for this most acceptable and quite unlooked-for mark of their approval of the slight services I may have rendered to Geological Science. While the gift itself will afford me material aid in the further prosecution of my palæontological studies, the thought that I have been deemed worthy of such a great distinction will add a new impulse to those labours.

The President next presented the second moiety of the Balance of the Proceeds of the Lyell Geological Fund to Mr. Thomas Roberts, F.G.S., and addressed him as follows:—

Mr. Roberts,—Among the most valuable methods for solving the great problems of stratigraphical geology is the one which has been chosen by yourself, namely, the direct comparison of a series of beds and of their characteristic fossils in one typical district with those of another and now isolated area. The Council of the Geological Society, hoping to encourage you in work of this kind, so well begun, have awarded you a portion of the Fund bequeathed to us by one who was among the first to recognize the value, and to pursue with success that method of research in which you are now engaged.

Mr. Roberts, in reply, said:—Mr. President and Gentlemen,—I beg to express my grateful acknowledgment of the honour the Council of the Geological Society have conferred upon me by the award of the moiety of the Lyell Fund. It is especially gratifying to me to find that the small contributions which I have hitherto been able to make to the Society have been thought worthy of recognition. In making the award the Council seem also to have taken into account the work involved in teaching others, and thus preparing myself for that accurate observation which is the first essential in Palæontological research.

It will stimulate me to further exertions; for there is still much to be done in the correlation of our Jurassic rocks as well as in other branches suggested to me by the rich collection in the Woodwardian Museum.

I hope, from time to time, to offer to the Society further contributions, and I shall be proud and pleased to co-operate with other workers in the same field, and to assist them in availing themselves of the magnificent collection in the Museum with which I am officially connected.

The President then read his Anniversary Address, in which, after giving obituary notices of Mr. Champernowne, the Rev. W. S. Symonds, Sir Julius von Haast, Mr. Robert Bell, and other deceased Fellows, together with notices of the Foreign Members and Correspondents of the Society who died during 1887—Studer, de Koninck, Desnoyers,

Hayden and Count Marschall,—he proceeded to congratulate the Society upon its flourishing condition, alike as regards its numbers, its finances, and the work which it has accomplished during the past year. The remainder of the Address was devoted to a discussion of the relations which exist between Geology and the Biological sciences. He insisted on the maintenance of Palæontology as a distinct branch of science, having equal claims upon the attention of Geologists and Biologists, and he instanced the life and work of Charles Darwin, as exemplifying the value and importance of a combination of Geological and Biological research.

The Ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—*President*: W. T. Blanford, LL.D., F.R.S. *Vice-Presidents*: John Evans, D.C.L., LL.D., F.R.S.; Prof. T. M'Kenny Hughes, M.A.; Prof. J. Prestwich, M.A., F.R.S.; Henry Woodward, LL.D., F.R.S. *Secretaries*: W. H. Hudleston, Esq., M.A., F.R.S.; J. E. Marr, Esq., M.A. *Foreign Secretary*: Sir Warington W. Smyth, M.A., F.R.S. *Treasurer*: Prof. T. Wiltshire, M.A., F.L.S. *Council*: W. T. Blanford, LL.D., F.R.S.; John Evans, D.C.L., LL.D., F.R.S.; L. Fletcher, Esq., M.A.; A. Geikie, LL.D., F.R.S.; Henry Hicks, M.D., F.R.S.; Rev. Edwin Hill, M.A.; W. H. Hudleston, Esq., M.A., F.R.S.; J. W. Hulke, Esq., F.R.S.; Prof. T. M'Kenny Hughes, M.A.; Prof. T. Rupert Jones, F.R.S.; Prof. J. W. Judd, F.R.S.; R. Lydekker, Esq., B.A.; Lieut.-Col. C. A. McMahon; J. E. Marr, Esq., M.A.; E. T. Newton, Esq.; Prof. J. Prestwich, M.A., F.R.S.; Prof. H. G. Seeley, F.R S.; Sir Warington W. Smyth, M.A., F.R.S.; W. Topley, Esq.; Rev. G. F. Whidborne, M.A.; Prof. T. Wiltshire, M.A., F.L.S.; Rev. H. H. Winwood, M.A.; Henry Woodward, LL.D., F.R.S.

II.—Feb. 29, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "An Estimate of Post-Glacial Time." By T. Mellard Reade, Esq., C.E., F.G.S.

The author showed that there exists on the coasts of Lancashire and Cheshire an important series of Post-Glacial deposits which he has studied for many years. The whole country to which his notes refer was formerly covered with a mantle of low-level marine Boulder-clay and Sands, and the valleys of the Dee, Mersey, and Ribble were at one time filled with these glacial deposits.

These glacial beds have been much denuded, especially in the valleys, where the rivers have cleared them out, in some cases, to the bed rock. Most of this denudation occurred during a period of elevation succeeding the deposition of the Low-level Boulder-clay. On this eroded surface and in the eroded channels lie a series of Post-Glacial beds of a most interesting and extensive nature. They consist of estuarine silt and *Scrobicularia*-clay covered by extensive peat-deposits, containing the stools of trees rooted into them. Upon these lie, in some places, recent tidal silts, and on the coast margin blown sand and sand dunes. The series of events represented by the denudation of the Low-level Boulder-clay and the laying down of these deposits is as follows:—1st, elevation succeeding the glacial period, during which time the Boulder-clay was deeply denuded in the valleys. 2nd, subsidence to about the 25-feet contour, when the estuarine silts and clays were laid down. 3rd, re-elevation representing most probably a continental connexion with the British

Isles, during which time the climate was milder than at present, and big trees flourished where now they will not grow. 4th, subsidence to the present level, the submersion of the peat and forest-beds, the laying down of tidal silt upon them, and the accumulation of blown sand along the sea-margin extending to a considerable distance in an inland direction.

It was estimated, from a variety of considerations, that these events, all posterior to the Glacial period, represent a lapse of time of not less than 57,500 years allotted as follows:—40,000 years for the elevation succeeding the Glacial period measured by the denudation of the Boulder-clay in the valleys, 15,000 years for the accumulation of the estuarine silts, clays, peat, and forest beds, and 2500 years for the blown sand.

2. "Note on the Movement of Scree-Material." By Charles Davison, Esq., M.A. Communicated by Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

The author noticed the frequent high angle of slope of screes, and called attention to Canon Moseley's observations on the downward creep of lead on the roof of Bristol Cathedral, and his subsequent experiment, and stated his belief that stones free to move on the surface of a scree must be affected in the same manner. This he proved by experiments, the result of which he described.

These experiments showed that stones do move downwards, owing to alternate contraction and expansion, the movements accompanying or occurring a short time after the change of temperature, that the descent is greatest on days of bright sunshine interrupted frequently by passing clouds, and that rain slightly increases the rate of descent.

A description was given of a scree on Hindscarth, Cumberland, in which the stones lie with their longer axes pointing down the slope; and it was pointed out that the movement of the stones in the way described would cause the surface-stones to fall off those on which they rested, and that others would be dislodged during their descent. A numerical estimate was then made of the total amount of movement produced on a scree of a certain size by expansion and contraction of the surface-stones, and after alluding to the relative efficiency of this and other agents upon various screes, the author concluded by pointing out that in the case of the moon this might be almost the only agent at work.

3. "On some Additional Occurrences of Tachylyte." By Grenville A. J. Cole, Esq., F.G.S.

An intrusive sheet, some eight feet thick, among the basalts of Ardtun Head in Mull, has selvages of tachylyte. The specific gravity of the glass is 2·83, and in other respects it resembles the examples already described from the west of Scotland. But in thin section, numerous fairly translucent spherulites are seen, which accumulate towards the inner part of the selvage until the glassy material between them disappears, and they become polygonal by contact. The rays of these spherulites are often alternately grouped in brown or greyer bundles, both series exhibiting striking pleochroism; but the brown fibres appear darkest when their longer

axes are parallel to the shorter diagonal of the Nicol's prism, while the greyish and less fibrous areas are darkest in the reverse position. The author believes that two distinct minerals are present, as in the spherulites of the ordinary granophyric structure; the browner rays may be pyroxenic, but the crystalline substances produced under these conditions of hurried consolidation may be far different from those developed in the more central portions of the mass. Spherulites with pleochroic rays are the normal type in basic glasses, and some occur even in some acid examples.

An analysis of the Ardtun spherulitic tachylyte shows it to resemble that of Beal in Skye, having 53 per cent. of silica and nearly 6 per cent. of alkalies.

An occurrence of tachylyte at Kilmelfort, Argyll, was noted, and a description given of an example of great beauty from the Quiraing in Skye. The latter rock shows, in section, a light-brown translucent glass, with abundant cumulites and small brown spherulites with radial structures.

Near Bryansford, County Down, in Ireland, a basalt dyke occurs, the selvage of which must must have originally resembled tachylyte of the Quiraing. The alteration that this glass has undergone guides one in the search for tachylytes (palagonite and so forth) among the Palæozoic rocks of the British Isles, and an instance was described from Snead, near Bishop's Castle, where fragments of basic glass are imbedded in a tuff of Ordovician age.

In conclusion, the well-known variolite of the Durance was cited as a rock of basic character, comparable, in its perlitic and spherulitic structures, with the acid "pyromerides," both types having alike suffered from secondary devitrification.

4. "Appendix to Mr. A. T. Metcalfe's paper 'On Further Discoveries of Vertebrate Remains in the Triassic Strata of the South Coast of Devonshire, between Budleigh Salterton and Sidmouth.'" By H. J. Carter, Esq., F.R.S. Communicated by A. T. Metcalfe, Esq., F.G.S.

A microscopic examination of certain calcareous pellet-like bodies, containing plates possessing a bony structure, and referred to in Mr. Metcalfe's paper in the Society's Journal for May, 1884, revealed the fact that the plates resembled the scales of the Bony Pike, and also the scales contained in certain Liassic coprolites which were identical in appearance with the Triassic pellets. The author concluded that the latter were the coprolites of Triassic amphibians which fed upon the same kind of Ganoid fishes as did the Ichthyosaurs of the Lias.

The author had also examined microscopically the so-called "spine," No. 1, fig. 2, and the jawbone, No. 2, of Mr. Metcalfe's paper, and observed that there appeared to be no difference between the structure of the latter and that of reptilian bones, whilst its structure is different from that of the Lepidostean scale; with regard to the former, he stated that it was totally different from the spines of two species of *Hybodus* examined, and considered that there were no grounds for considering it a spine.

III.—March 14, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.

The President announced that it is proposed to build, in memory of the late Mr. Champernowne, a moderate-sized cottage hospital in Totnes. Mr. Champernowne was greatly interested in a temporary hospital, erected in 1885, and was anxious that a permanent institution should be established for the same purpose. The cost is estimated at about £900 or £1000, of which between £500 and £600 have been subscribed in sums varying from a few shillings upwards. Fellows of the Society wishing to contribute to this memorial should send at once to Dr. Currie, Bridgetown, Totnes, Devonshire, or to Archibald Geikie, Esq., F.R.S., 28, Jermyn Street, S.W.

The following communications were read :—

1. "On the Gneissic Rocks off the Lizard." By Howard Fox, Esq., F.G.S., with Notes on Specimens by J. J. H. Teall, Esq., F.G.S.

The rocks may be classed under three heads :—(i.) the coarse gneisses of Mên Hyr type, (ii.) the light-banded granulitic gneisses or Wiltshire type, and (iii.) the transition micaceous rocks of "Labham Reefs," type intermediate between (ii.) and the mainland schists.

The first are seen in Mulvin, Taylor's Rock, Man-of-war Rocks, the Stags, Men Par, Dlidgas, Mên Hyr, and Vasiler; the second in Sanspareil, the Quadrant, and adjoining reefs, Labham Rocks, etc.; and the third in the Labham Reefs.

The inclination of the divisional planes appeared conformable with that of the rocks of the mainland.

The genisses and granulites of several of the islands are traversed by numerous dykes of porphyritic basic rock, seen in Taylor's Rock, Man-of-war Rocks. Sanspareil, Quadrant Rock and Shoals, and Clidgas. These dykes have been disturbed by movements subsequent to their intrusion. They sometimes strike across the foliation-planes of the gneiss and send veins into the latter rock; at other times the strike is parallel to that of the foliation-planes; the two modes of occurrence are occasionally observable in different portions of the course of the same dyke, *e.g.* in one traversing that part of the Man-of-war group known as the Spire. This dyke is also noticeable from the fact that it appears to be traversed by veins of gneiss.

The dykes vary in width from 18 inches to several feet.

In his notes on the specimens Mr. Teall says that the rocks may be arranged in four groups :—

1. Principally occurring in the outer islands, are of the Mên Hyr type, consisting of felspar, quartz, dark mica, and hornblende; the quartz and felspar sometimes exhibit relations characteristic of igneous rocks, at other times they form a fine-grained granulitic aggregate, the latter being probably the result of dynamic metamorphism. This granulation is carried to a greater extent in some of the islands, as in Taylor's Rock. The rocks possess the mineralogical composition of quartz diorite, and may be termed tonalite-gneisses; they may originally have been eruptive tonalites.

2. Occurring chiefly in the inner islands, are of the nature of granulitic gneisses and granulites, confining the latter term to rocks in which the quartz and felspar are present wholly in the form of a micro-crystalline mosaic of fairly uniform grain. In some of these foliation is not well marked. Such rocks occur in "Wiltshire," etc.

3. Rocks showing a passage from the granulitic rocks to the mica-schists of the mainland, as the brown schistose rocks of Labham Reefs. The Enoch rock, a coarse quartzless hornblende schist, also has affinities with the mainland schists.

4. Dykes traversing the gneisses, consisting of porphyritic felspars lying in a ground-mass of hornblende and granulitic felspar. The hornblende is probably secondary after augite, and the rocks epidiorites. These dykes have been affected by deformation, and sometimes pass into actinolite schists near the junction with the gneissose rocks.

In conclusion, the period of dynamic metamorphism, of which the most striking results are seen in the schists of the south-western portion of the Lizard peninsula, was posterior to the formation of the basic dykes. There is no evidence of igneous action in this district since the period of metamorphism.

2. "The Monian System." By the Rev. J. F. Blake, M.A., F.G.S.

The object of the author was to show that the whole of the rocks which, under various names, had been described as Pre-Cambrian in Anglesey, constitute a single well-characterized system, of which the various divisions hitherto described are integral and inseparable parts.

The evidence of these rocks being Pre-Cambrian was first discussed, and it was shown that the greater part of it went no further than to prove them Pre-Ordovician, the basal conglomerates being associated with rocks of Arenig age, though from the occurrence of these conglomerates on Holyhead Island it was inferred that the previous denudation had been great. The rocks of the eastern district, however, are proved to be Pre-Cambrian from the basal Cambrian rocks of Bangor type lying on them unconformably near Beaumaris and near Redwharf Bay. The rocks described are found in six distinct districts in Anglesey.

1. *The Western District.*—The lowest rocks are the great quartzites of Holyhead, which pass at Porth-yr-ogof and inland into chloritic schists, which are foliated in planes of lamination, and thus is produced a tough rock which will not cleave or break, but bends into minute contortions. Towards the east this becomes finer in grain, and may be distinguished as chloritoid schist. On the side of the Straits near the valley it may be seen passing into purple slate. Further north the rocks are confused, especially at Porth-y-defaid, but there is no well-defined fault. The material becomes irregular and forms rocks described as "marbled slate," "lenticular perlites," and soft tuffs. Amongst such are found two special features, viz. masses of quartz in the form of knobs, and lenticular patches of limestone. These it is suggested were produced by the agency of springs rising through and into the ashy rocks. They are especially characteristic of this part of the series. The granite of Pen-bryn-

yr-Eglwys is intrusive, and its junction may be seen in several places, the surrounding rocks developing mica. It is here therefore the youngest rock.

On the south-west side of a fault in Holyhead Island and the neighbouring mainland occurs a distinct group of rocks, continuous upwards from the chloritoid schists, and equivalent to the volcanic facies of the north. These are called the South Stack series. They are characteristically bedded, thrown into large folds, sporadically cleaved, and possess cleavage-foliation. They contain great beds of quartzite, and others of light dusty material. When not cleaved, they are almost entirely unaltered.

The spot near Tywyn, supposed to show fragments of granite contained in a rock of the upper series, and hence the conformity of the two, shows only an intrusive diabase which has caught up granitic fragments.

2. *The Central District.*—This is divided into two parts by a fault. That on the east consists of grey gneiss, considered to be the lowest rock of the whole series, with the quartzite at Bodofon as an episode, followed after a fault by chloritoid schists, so intimately connected with the overlying volcanic facies as to be inseparable. The principal features of the latter are the agglomerates of Llangefni, the quartz knobs, and the more or less bedded sporadic limestones. The portion on the west consists of ashes and fine hälleflintas, together with gneissose rocks of no great similarity to the grey gneiss. These have been so interfered with by intrusive rocks that it is difficult to ascertain their true original character. These intrusions consist of (1) Diorite, often foliated, with the folia contorted, and affording by its brecciation some portion of the surrounding rocks. (2) Granite, seen everywhere to be either intrusive, as at Porth-y-dee, Ceryg-defaid, Craig-y-allor, and Maen-wyn, or absorptive, as near Llyn-faelog. This granite is of various kinds, often passing into a felsite.

3. *The District west of Traeth Dulas* shows granite intrusive into grey gneiss, and also passing into a felsite ; it is correlated with the western half of the central district, of which it appears to be a continuation.

4. *The Eastern District.*—The lowest portion here is the grey gneiss, which is very compact towards the west. especially near the igneous rocks, but becomes more micaceous and chloritic towards the east, passing through chloritoid rocks into others of the volcanic facies, with the usual quartz knobs and sporadic limestones, but here, on the whole, more slaty. The complete unity of the whole system is here well seen. The most remarkable feature is the intrusive foliated diorites, which are coarse and non-foliated near Holland Arms, but became finer towards the east, where also glaucophane takes the place of hornblende. They are seen intruding into and contorting the grey gneiss in the Llangaffo cutting.

At the southern end at Careg-gwladys is a remarkable volcanic group, with a spherulitic diabase breaking into and surrounding the baked blocks of calcareous slate. There are associated great masses

of mixed agglomerate, and terminated masses of limestone and quartzite filled with brecciated fragments.

5. *The Northern District.*—This commences in the south with the chloritic schists, but soon becomes slaty, and such rocks with grits occupy the greater part of the area. But towards the north we reach the volcanic facies, characterized as usual by ashes, agglomerates, quartz knobs, in one place near Bull Bay, seen to cross the bedding, and sporadic limestones at Llanbadrig, showing oolite within oolite, and suggesting its origin by a petrifying spring. Above the quartz is found a great conglomerate, apparently derived from it, and immediately above this conglomerate occur the fossils discovered by Prof. Hughes, and no line of separation can be discovered between them and the rest of the rocks in the district. These fossils have been referred to Bala species, and there are three alternatives to choose: either (1) they are not Bala fossils, but are characteristic of the Pre-Cambrian rocks; or (2) they are Bala fossils, and the dividing line has as yet been missed; or (3) there is no dividing line, and the whole series is of Bala age. Against the latter is their similarity to the rocks of the eastern district definitely overlain by Cambrian; and against both the two latter is the fact that the series is unconformably overlain in the neighbourhood by other conglomerates succeeded by black shales in which Llandeilo Graptolites have been recorded.

6. *The District north-east of Parys mountain* is a volcanic complex, in which granite and felsitic rocks with others of a more basic character are inextricably mixed with the débris of the same materials, and both are altered so as to be, in most places, inseparable. This is connected on the N.W. side with grey gneiss.

In the *Lleyn* the rocks belong to the volcanic facies, in which great masses of quartz-felsite, foliated at the edges, are intruded. Here also are found the quartz knobs and sporadic limestones as well as diabase-flows. At Mynydd ystum is found an isolated patch of grey gneiss.

The area between Bangor and Caernarvon has lately been shown to contain some felsite-flows, and also granites, apparently intrusive into ashes, which may belong to the volcanic facies.

At *Howth*, near Dublin, the rocks have all the characters of the South-Stack series, to which they may be correlated; and these are followed upwards by the well-known Bray-Head rocks, which differ from them in character, but whose fossils are not of Cambrian species.

The succession thus shown in the various districts consists of the following in ascending order. The grey gneiss, becoming more quartzose, micaceous, or chloritic in parts, and so representing the quartzite and the chloritic schists of other districts; changing through chloritoid schists into two facies, viz. (1) the slaty, represented best in the northern district, and also as the South-Stack series; and (2) the volcanic facies. No further deposits are recognized in the areas of the volcanic facies, but in the slaty area of Howth the Bray-Head rocks succeed.

To the whole system of rocks the name of Monian is applied, as

derived from Mona, or the Isle of Anglesey, and the several parts are distinguished as the *Holyhead group*, or Lower Monian, the *St. David's group* and the equivalent of the *South-Stack Series*, or Middle Monian, and the *Bray-Head group*, or Upper Monian.

The "Pebidian" represents the St. David's group, and but for its termination, which indicates a system, might be used as an alternative. The "Dimetian and Arvonian" are intrusive granites, or felsitic flows associated with the same group.

The Monian system, though much metamorphosed in its lowest parts, is not considered Archæan, but as a lower sedimentary system than the Cambrian, and hence the lowest system of our ordinary stratified rocks.

CORRESPONDENCE.

THE CAUSES OF THE GLACIAL AND MILD PERIODS.

SIR,—There is a theory on the above subject (due to M. Poisson, I believe) which seems to me worthy of more attention than it has recently received from geologists, viz. that the earth with the entire solar system has travelled through hotter and colder regions of space at different periods. Hotter and colder regions of course mean regions in which it received more or less heat from the stars.

Now that the solar system is moving with considerable velocity through space may be regarded as an established fact, and though it may not have materially changed its position among the stars in historical time, it is otherwise with regard to the much longer geological periods. Mr. Maxwell Hall indeed recently computed that the solar system is moving round a distant centre in a period of 13 or 14 millions of years, though his data I think must be regarded as uncertain. Further, every astronomer knows that there are richer and poorer regions among the stars, the passage of the solar system through which would materially affect the amount of stellar heat.

But it may be thought that the total amount of stellar heat is insignificant compared with solar heat. The observations of Pouillet and Herschel however point to an opposite conclusion. The mean temperature of the earth is more than 500° F. above the absolute zero, of which according to them not more than 300° F. is due to solar radiation. The remaining 200° F. must be ascribed to the heat of the stars. An increase or diminution of 10 per cent. in this would raise or lower the mean temperature of the earth by 20° F., and such an increase confined to the Northern sky would make the North hemisphere 20° F. hotter than the Southern.

I am aware that the results arrived at by Pouillet and Herschel are doubted by many. Further experiments on the same subject by skilled physicists are much to be desired. And should these experiments result in showing that the total amount of stellar heat is insignificant, this fact would not be altogether favourable to the theory of Dr. Croll. If the solar heat is competent to raise the temperature of the earth by 500° F. instead of 300° F., the

increase of $\frac{1}{160}$ which takes place at the maximum eccentricity is competent to raise the mean temperature of the earth by nearly 2° F.; and this increase of heat being maintained for thousands of years could not fail to affect the position of the lines of perpetual snow. Whether there would be an actual increase of 2° F. in the mean temperature I need not discuss, because as regards the formation and dissipation of snow and ice the essential element appears to be the quantity of heat absorbed in the course of the year.

13, Belvedere Place, Dublin, *Feb.* 27. W. H. L. Monck.

ON THE CORRELATION OF THE GRÈS DE BELLEU WITH THE LOWER BAGSHOT.

Sir,—In discussing Prof. Prestwich's new correlation of our Eocenes, I could not help calling attention to the fact that while in his table the position of the Grès du Soissonnais would be below the London Clay, its Flora coincided with that of our Lower Bagshot at Alum Bay, above the London Clay. This apparent anomaly is capable of explanation.

The only comprehensive publication on the Flora of the Paris Basin is by Watelet, and though his determinations possess little interest, the illustrations are sufficient in most cases for comparison. The plants represented therein are mainly from Sézanne and Belleu, with a few from other localities. The precise age of the *travertins* of Sézanne is, in the absence of direct stratigraphical evidence, an unsolved problem, but the aspect of its flora is so ancient that it is difficult not to agree with Saporta, Schimper and others who place it in the Pal-eocene. It is in fact allied rather to the newest Cretaceous floras of Europe than to any Eocene flora, and its nearest representative in our country is the flora of Ardtun in Mull. The few plants from the *Grès "intercalés dans les Sables de Bracheux"* and from the Lignites are insufficient to tell us anything, but those from the *Calcaire Grossier* are well-marked Bournemouth species. It is with the vast majority, however, from the *Grès de Belleu*, that we have to deal, and these we cannot hesitate in correlating with our Lower Bagshot of Alum Bay. The forms common to the two are a Fern, the Palms, all those highly characteristic forms called *Comptonia* and *Dryandra*, the large *Ficus Bowerbankii* and other species of *Ficus*, *Laurus? Salteri*, *Quercus* or *Castanea eocenica*, a supposed *Cinnamomum Larteti*, the flower called *Porana*, leaves of *Acer*, and bean-pods of *Acacia* and *Cæsalpinia*. The *Podocarpus elegans*, *Marattia Hookeri*, and particularly the *Aralia primigenia*, so characteristic of Alum Bay, are absent, but the two former are equally absent in the corresponding beds so close at hand as Studland. On the other hand, the Belleu beds are far richer in the trinerved leaves known as *Daphnogene* and *Cinnamomum*. Such differences are, however, always met with in separate patches of plants, even if on precisely one horizon and near each other, and do not suffice to affect the main fact, that the facies of the floras is as a whole the same, and very different indeed to any flora above or below them. I have had large series of the plants from both

localities pass through my hands, and the similarity is beyond all question. Now these plants are found in the Grès "*supérieurs aux lignites.*" The Lignites themselves rest in the neighbourhood of Paris on mottled clay, absolutely identical with that of our Reading beds, and are the undoubted equivalents of the Woolwich series, consisting of stiff bluish clay with blackish bands and some fossil wood, exactly as in the Croydon cutting. Immediately on their eroded surface we find the calcareous Bracklesham beds with *Nummulites lævigata*, so that there is a hiatus in the Paris area represented in our series by the Oldhaven, London Clay, and Lower and Middle Bagshot.

We may place the Grès de Belleu anywhere in this interval, and the only reasonable conclusion to be drawn is that they do not belong to the Soissonnais series at all, but lie on it unconformably, or only apparently conformably on it, just as our Lower Bagshots lie on the London Clay at Alum Bay. In this case, while Prof. Prestwich's correlation of the "London sands" or marine so-called Lower Bagshot with the sands of Cuise-la-Motte and the Upper Ypresian is unaffected, the totally distinct fresh-water and true Lower Bagshot will also have its equivalent in the Paris Basin.

The suspected connection between the Floras of Alum Bay and Sheppey is strengthened by the flora of these *Grès*, for I have recognized quite a number of casts of fruits in them which are identical with Sheppey forms. J. Starkie Gardner.

LARGE IRISH BOULDERS.

Sir,—In the Co. Galway, as mentioned in my Geology of Ireland, p. 248, also in the Geol. Survey Memoirs, the boulders are larger and more numerous than elsewhere in Ireland, much larger than any I have seen in the Co. Wicklow. The Ballagh Stone, a few miles N.W. of Galway, is about 21 × 24 × 20 feet. Clogh Currill is as large, and very like one of the ancient castles, while many others are much larger than the ordinary cabins of the country; they are all granite blocks. Huge limestone blocks once existed on the sandstone ridge near Ballingarry, Co. Limerick, but I am afraid that now they are all quarried away and burnt into lime (Geol. Survey Mem.). In the Co. Waterford Du Noyer drew attention to the huge conglomerate blocks, some of which he figured (Geol. Survey Mem.). The largest I saw was Clogh-na-Kilcluney, to the S.E. of the Comeragh Mts. One nearly as large is Clough-lowrish, figured by Du Noyer. In the Co. Wicklow, Wyley seemed to consider the largest to be that of Boleynass, near the Devil's Glen. Kath boulder, near the Bush Railway Station, Co. Louth, is 32 × 20 × 9 feet (Geol. Survey Mem.). In this district there are many whinstone blocks of large dimensions. S.W. of Ballina there are many erratics referred to years ago by Sir R. Griffith and Archdeacon Verschoyle. One granite block N.W. of Carrowmore has been calculated to exceed 415 tons in weight (Geol. Survey Mem.). G. Henry Kinahan.

Geological Survey of Ireland,
14, Hume Street, Dublin.

THE METAMORPHIC ROCKS OF SOUTH DEVON.

SIR,—The writer of the letter printed in your January issue on this question (p. 46) does not seem quite to recognize the position which the microscope occupies in the investigation. As Professor Bonney in his previous letter to your journal kindly alluded to my work in the district under discussion, I may perhaps be allowed briefly to indicate the point, which, as it seems to me, is rather overlooked by Mr. Somervail. How he can have supposed Professor Bonney has anywhere stated that the microscope in geology is "everything" to the exclusion of field-work I cannot understand, for I remember more than one passage in which the opposite opinion is expressed.[1] The two modes of investigation are two independent witnesses, and the question is, can there be any value in a result founded on the one testimony alone, when an investigator, extremely well qualified to interrogate both, has come to an opposite conclusion? It is not even as if the two methods result in a complete contradiction. It is rather that the rocks at Hall Sands form one of those difficult cases where the unaided eye can scarcely be trusted. Here we find, almost in juxtaposition, a "schistified" fragmental rock and a "fragmentalised" schist. The question then is, can we draw a line of separation between the two? He who relies on field evidence alone may say, I cannot see it; but the worker with the microscope replies, There is a clear distinction. The positive statement, which is the result of employing the more delicate process of investigation, must surely be of the greater value; and in such case one could not rely on a hesitating or negative answer, which had been the only outcome of the more rough-and-ready method. But, in my opinion, even the field evidence is strongly in favour of the distinctness of the two series of rocks, when we take into consideration the sections, which occur elsewhere than at the coast of Hall Sands. The evidence of an abrupt change from a crystalline to a non-crystalline rock seems to me perfectly clear, not only at Hope Cove, but also along the estuary shores north of Salcombe and towards South Pool, and inland near Killington.

I was especially interested, in my first visit to the district, in the chlorite schist quarries near Hall Sands,[2] which are described in the article in the Devonshire Transactions; for this occurrence of chlorite schist completely disposes of any theory of progressive metamorphism. Certainly there can be no gradation from the slates of Hall Sands to chlorite schist. But I am puzzled by Mr. Somervail's statement that this chlorite rock reappears in the valley "on the north of Professor Bonney's junction, where according to his view it has no right to occur." The chlorite rock occurs to the south of the valley, and I do not understand on what grounds it is asserted to be north of the junction. Professor Bonney indicates the fault by a dash, which necessarily on a map of so small a scale,

[1] GEOL. MAG. 1880, p. 299; and 1879, p. 203.

[2] In my map as published in the Quarterly Journal, two lines, which unfortunately escaped my notice, have been accidentlly introduced, making it look as if slate existed in the Bickerton quarry in contact with the schist. The quarry, as described by Mr. Somervail, is entirely of chlorite schist, with slickensided bands.

covers some inland country, but, as is clear from his description, he limits himself to the coast, and did not attempt to trace the faults inland, so that no arguments can be founded on the length or direction of this line, any more than on the breadth of the zone shaded to represent the occurrence of this or that rock in the cliffs. At Hall Sands the chlorite rock is not seen in situ along the shore, though it may exist beneath the sand on the south part of the beach. But I do not believe that it would occur, as seems to be suggested by Mr. Somervail, further to the north, because before that it would be cut out obliquely by the boundary fault.

To conclude:—as to the proof of a fault, I believe that if Mr. Somervail undertakes a microscopic investigation, after having gone through his intended course of study with that instrument, he will find that the strata are, as he demands, "thoroughly opposed to each other in mineral aspect." While the result of field-work is, that beds of chlorite-schist and of mica-schist strike up towards a certain boundary-line, and seem to be there cut off, which is surely suggestive of the existence of a fault. C. A. Raisin.

85, Hungerford Road, N.

MISCELLANEOUS

The New Professor of Geology at Oxford.

We are much pleased to announce that Mr. A. H. Green, M.A., F.R.S., F.G.S., has been elected to fill the office of Professor of Geology in the University of Oxford, a post rendered vacant by the retirement of Prof. Prestwich. Mr. Green, who is a Cambridge man, was Sixth Wrangler in 1855, and was subsequently a Fellow of Caius College. In 1861 Mr. Green was appointed an Assistant Geologist on the Geological Survey of Great Britain, and in 1867 he was promoted to the rank of Geologist; during his service he surveyed considerable areas of the Jurassic and Cretaceous rocks in the Midland counties, and of the Carboniferous rocks in Derbyshire, Yorkshire, and other northern counties. Many Survey Memoirs have been written wholly or in part by Mr. Green, among which we may mention the Geology of Banbury (1864), and the geological descriptions of the country around Stockport (1866), Tadcaster (1870), Dewsbury (1871), Barnsley (1878), and Wakefield (1879). The memoir on the Geology of North Derbyshire, of which the first edition was published in 1869, was written chiefly by Mr. Green, and the second edition, published last year, contains additions by him. His most important Survey work is the Geology of the Yorkshire Coal-field (1878).

In 1874 Mr. Green was appointed Professor of Geology in the Yorkshire College at Leeds, and while he completed some official Survey work after that date, he also published in 1876 a Manual of Physical Geology, a work which has taken a leading place as a text-book for students and teachers on this branch of the science; a third edition was issued in 1882. We may mention that for several years Mr. Green held the Lectureship on Geology at the School of Military Engineering at Chatham; until the authorities at

the War Office came to the conclusion that education in this science was unnecessary!

It is interesting to note that most of our Geological Professors have served their apprenticeship on the staff of the Geological Survey; these include Professors Hughes, Hull, Judd, James Geikie, Boyd-Dawkins, Young, and Lebour.

THE DAVIDSON MEMORIAL.

THE marble medallion portrait of the distinguished palæontologist, Dr. Thomas Davidson, LL.D., F.R.S., by Mr. Thomas Brock, A.R.A., was unveiled on Friday afternoon, at three o'clock, in the geological room of the Free Town Museum, by the Mayor of Brighton (Mr. E. Martin). As the ceremony had been unavoidably postponed, the day unfortunately coincided with that of the Anniversary Meeting of the Geological Society. Prof. J. W. Judd, F.R.S., the President of the Society, communicated a feeling tribute to the worth and scientific attainments of Dr. Davidson; and Sir Richard Owen, K.C.B., President of the Palæontographical Society, also wrote expressing his sympathy, and regrets that failing health prevented his paying the respect of personal attendance to the memory of his distinguished fellow-worker.

The Memorial was presented to the town on behalf of his fellow subscribers by Mr. Edward Crane, F.G.S., Hon. Sec., and Chairman of the Museum Committee, who referred in detail to Dr. Davidson's life-long scientific labours on the Brachiopoda, the honours bestowed on him for these researches, and the valuable services he had rendered to Brighton in the formation of the Free Museum, when the British Association visited the town in 1872, and in furthering its subsequent development. The Mayor suitably acknowledged the gift, which, he said, would always be respected and preserved as an enduring memorial of a most distinguished scientific man and fellow-townsman.

The small balance of the fund available will be expended in some addition to the Museum Collections by the joint Hon. Secs., E. Crane, F.G.S., and J. E. Haselwood, F.R.M.S., who beg to express here their warm acknowledgments to all the personal and scientific friends and subscribers to the Davidson Memorial both at home and abroad.

The Medallion is a splendid life-like presentment in *alto relievo* of Dr. Davidson in the prime of life. It is framed in moulded alabaster, and is a highly finished work of art. Placed in a conspicuous position in the geological room, it forms a most artistic adornment to the walls of the Museum. The following inscription in gilt letters is placed on an oak panel beneath the Medallion:—

THOMAS DAVIDSON, LL.D., F.R.S., F.G.S.

Wollaston Medal 1865. **Royal Society's Medal 1860.**

First Chairman of the Brighton Museum Committee.

Presented to the Town Feb. 17th, 1888, by the Subscribers to the "Davidson Memorial Fund."

THOMAS BROCK, A.R.A., Sculptor. **EDWARD MARTIN, Mayor.**

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. V.

No. V.—MAY, 1888.

ORIGINAL ARTICLES.

I.—On the Mollusca of the Pleistocene Gravels in the Neighbourhood of Cambridge.

By Mrs. McKenny Hughes.

THE site of Barnwell Abbey has long been excavated for gravel. The pits have been easily accessible to collectors, and have for many years yielded large numbers of Mammalian bones, Mollusca, and a few plant-remains.

These gravels were noticed by the Rev. P. B. Brodie and Prof. Sedgwick in 1838.[1] Prof. Seeley gave a sketch of them in the Q. J. G. S. 1866, in which there was a list of the land and fresh-water shells drawn up by Mr. Dewick. They were described by Mr. Jukes-Browne in his essay on the Post-Tertiary deposits of Cambridgeshire, 1878, and in the Memoir of the Geological Survey.[2] A list of the species preserved in the Woodwardian Museum was given by Prof. Hughes in the Geological Magazine in 1883. Exact references to some of these papers and to others in which the deposits are mentioned will be found in Mr. Whitaker's list of works on the Geology of Cambridgeshire, privately printed for the Woodwardian Museum in 1873, and reissued with the Geological Survey Memoir above referred to. A list of shells from the Barnwell Gravel is given by Dollfus.[3]

Whenever any fresh excavations are made in this district, new evidence is generally obtained as to the relations of beds, and the distribution of the life of the period; and it seems desirable to place on record at once any additional facts observed in deposits which are being entirely removed, such as the Barnwell Abbey gravel, and to call attention to any hitherto undescribed sections, such as those near Barnwell Station, at Grantchester, or in the pits west of Barrington Green.

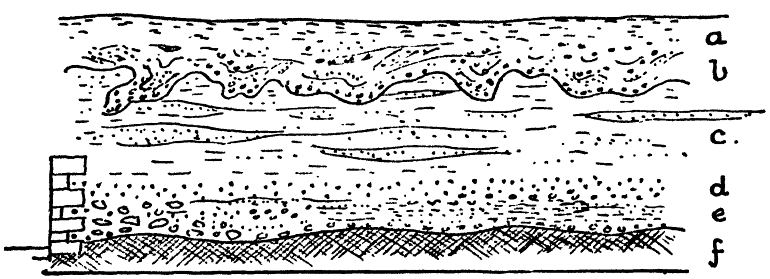
Within the last few years Barnwell Abbey has been acquired by Mr. Sturton, who has laid out the ground in building plots, having previously removed almost the whole of the surface gravel. Mr. Sturton has with great liberality presented to the University what remained of the old Abbey and a piece of the ground around it, and has offered every facility to geologists for examining the sections during the progress of the work. Thus an exceptional opportunity

[1] Trans. Camb. Phil. Soc. vol. viii. 1844, part i. p. 138.
[2] Explanation of Sheet 51 S.W. 1881.
[3] Le Terrain Quaternaire d'Ostende, etc., Bruxelles, 1884.

has been offered for observing the relative position of the beds in which the different species were more or less abundant. None of the shells were confined to definite zones; nor were they distributed through beds bearing any constant relation to one another; but, at varying horizons, and in different parts of the field, lenticular masses and pockets occurred, in which certain species were very abundant, while others were absent there which were common above or below, or at the same horizon close by; whereas, not far off they would be found mixed together in the same bed. In former excavations, in one part of the field, plant-remains were found in abundance near the base of the gravel. Among these were a few *Chara* spores and a quantity of leaves and twigs which are considered by Mr. Clement Reid to belong to one species of *Salix*—probably *S. repens*. From the recent diggings very few plant-remains have been obtained; only an obscure fragment here and there.

It is clear that gravel-pits of inconsiderable size opened in closely adjoining parts of the field might yield a very different group of fossils; but the removal of the whole showed that this depended upon small local variations of the same set of deposits. For instance. there were, in one case associated with Mammoth near the top, and in another resting on the Gault at the very base of the deposits (see

Fig. 1.—Section seen by Ancient Well North of Ruin, on site of Barnwell Abbey. Scale—10 feet to 1 inch.



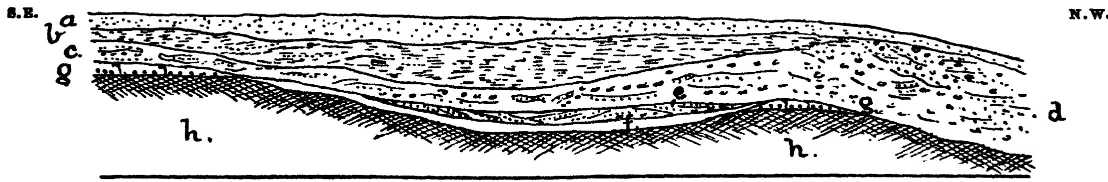
a, Surface soil, etc.; *b*, Irregular gravel; *c*, Fine sand and marl: *d*, Reddish sand; *e*, Coarse gravel consisting in places of large subangular flints with a few boulders derived from the drift and passing horizontally into fine beds of chalky gravel and marl full of shells, chiefly *Bythinia*, *Corbicula*, *Unio*, *Valvata*, *Planorbis*, etc.; *f*, Gault.

Section Fig. 1), lenticular marly beds containing shells and opercula of *Bythinia* in great abundance. In some places no specimen of *Corbicula* (*Cyrena*) could be found; still more often *Unio litoralis* was absent, although these shells occurred somewhere at every horizon. Except, therefore, in the case of very extensive excavations, generalizations, especially where founded largely on negative evidence, must be considered only as tentative.

In the gravel-pits at the other side of the Newmarket Road no shell-bearing beds are now exposed, although a few years ago *Unio litoralis* occurred abundantly in the N.W. corner of the pit, but lower than the level of the present workings.

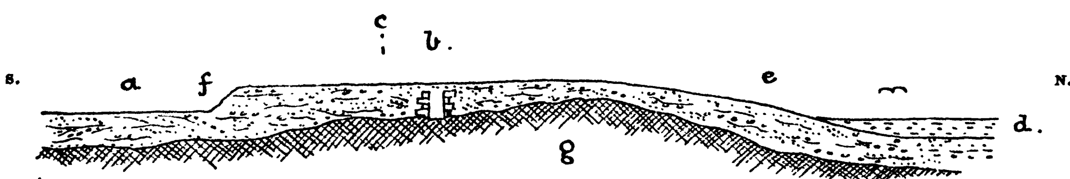
Following the gravel due north we come to the brick-pit at

Fig. 2.—Section in Brick-pit between Barnwell Station and Stourbridge Common. Scale—20 feet to 1 inch.



a, Rusty sand; *b*, Buff sandy loam, darker where damp, some cross-bedding, lines of more sandy loam weathering out; *c*, Gravel, split up by beds of sand and loam at S.E. end; *d*, Gravel: falling over bank to lower level of Stourbridge Common; *e*, White sand and gravel with shells, which runs higher further west; *f*, White marl, such as might be derived from the Chalk-marl, and bands and pockets of re-sorted phosphatic nodules; *g*, Remains of Chalk-marl and Cambridge Greensand running into *f*; *h*, Gault.

Fig. 3.—Section Across the Barnwell Abbey Gravel. Length of Section, 500 feet.



a, Old gravel-pit, the bottom partly refilled; *b*, Ancient well; *c*, Position of ruin; *d*, Alluvium, etc.; *e*, Gravel north of bank of Gault; *f*, The Barnwell Abbey gravel; *g*, Gault. Further west the Phosphate Bed comes on at a lower level than that at which the Gault occurs here, and further east, at a somewhat higher level, there is a capping of Chalk-marl.

Barnwell Station; here the gravel is seen resting on the Gault, which is in places troughed in such a manner as to suggest the beds of ancient streams (see Section Fig. 2).

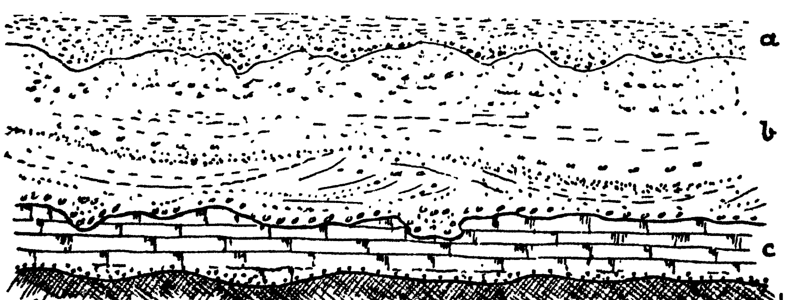
There seems to be one such old channel here at the margin of the gravel, running parallel to the present river-valley. *b*, *c*, *d*, and *e* of the section are river deposits which have filled it up; some of the looping is perhaps caused or increased by the decomposition of underlying chalky beds. The channel here and there cuts just into the top of the Gault, and patches of the overlying Chalk-marl and Phosphate Bed are left; the banks seem to have fallen in in places, and the gravel has sunk into the puddled surface of the clay, so that the Gault, Phosphate Bed and gravel are sometimes kneaded up together in the most irregular manner. The gravel (*c*) thickens out to the west, and falling over the slope to the lower ground forms the main mass of the bank next Stourbridge Common, and corresponds to the gravel near the Holy Well at Barnwell Abbey, which in like manner lies on the west slope of a bank of Gault (see Fig. 3).

This western portion, both here and at Barnwell Abbey, forms the margin of a lower terrace, which being directly derived from the higher level gravels, can hardly be distinguished from them on the ground. The deposit in which the shells occur at Barnwell Station (*e*) is older than this flanking gravel, as, at Barnwell Abbey, the shell-bearing strata are older than the gravels west of the Gault ridge, and between it and the river. When, however, we have to consider the relative age of the shell-beds at Barnwell Station and those at Barnwell Abbey, we find that the question is more complex. The lie of the ground seems to point to their being part of the same mass, but the character of the deposits seems to indicate that though they belong to approximately the same age, they were nevertheless laid down under somewhat different conditions.

With the interruption of the lower level gravels of the Cam Valley, described by Mr. Jukes-Browne, we find beds similar to

Fig. 4.—Section South of Grantchester.

Scale—10 feet to 1 inch.



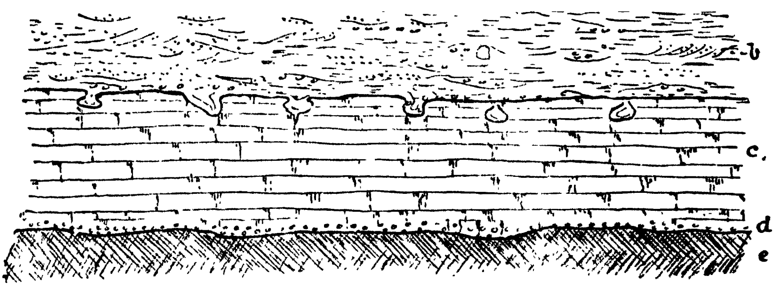
a, Surface soil and rusty gravel from which the Chalk has been dissolved out; *b*, Chalky gravel and marl with pans of peaty silt and bands full of land and freshwater shells; *c*, Chalk-marl and Phosphate Bed; *d*, Gault.

those at Barnwell covering a large area near Shelford, where also *Corbicula fluminalis* is found, and extending by Trumpington to the well-marked terrace of Grantchester

The Grantchester gravel (see Section Fig. 4) occurred in irregular masses troughed into the underlying Chalk-marl, and was exposed by the removal of the whole of the surface in the process of digging for phosphate nodules. It was not clear that it bore any relation to the existing geographical features; but its irregularity and the presence of pans of decomposed vegetable matter and of masses of shells buried in chalky loam, seemed to indicate accumulations along the shifting channels of a river wandering over a tolerably wide area, and deriving much of its material from older gravels, from Boulder-clay, and even directly from the Chalk-marl which it here and there touched in its course. All the shells in the Woodwardian Museum were obtained from one rich deposit of small extent close to the farm track, just beyond the S.W. corner of the camp, at a depth of about 5 to 8 feet from the surface. This pit is now filled up, and although there are here and there openings from which sand and gravel are being dug, no shells have been found in them; nor are any beds now exposed exactly similar to those from which the shells were formerly obtained. The list of Mammalian remains and shells given in Column II. p. 202, has not hitherto been published.

Beyond Grantchester, about four miles to the south-west, the village of Barrington stands on a terrace on the left bank of the River Rhee. This terrace consists principally of loam derived from the Chalk-marl with lines and lenticular beds of sand and gravel to a depth of from 5 to 10 feet.

FIG. 5.—Section seen in pit north of Windmill, near Westgate Farm, Barrington. Scale—10 feet to 1 inch.



a, Surface soil. 1′—2′; *b*, Chalky loam and sand, with small lines and lenticular beds of gravel. At the southern or lower end of the digging the gravel and sand is looped into the top of the underlying Chalk-marl. 6′—7′; *c*, Chalk-marl; *d*, Cambridge Greensand; *e*, Gault.

The gravel does not appear on the 1-inch Survey Map, probably because at the time that map was made there was nothing at the surface to distinguish the loam which belonged to the gravel from the decomposed surface of the marl, etc. In subsequent phosphate

diggings, however, on the north-east side of the village, this deposit was exposed and described by the Rev. O. Fisher,[1] and referred to in the Survey Memoir.[2]

About a mile and a quarter W.S.W. of these pits, north of the Windmill, on the other side of Barrington Green, extensive excavations for phosphate have recently exposed other sections in what is the continuation of that terrace, or if now cut off from it by the little valley west of Barrington Green, was originally part of the same.

From the character of the workings, the whole of the deposits belonging to the gravel age can be seen down to the base, where they rest upon the Chalk-marl (see Section Fig. 5). They consist largely of materials derived from the Chalk-marl and from the Boulder-clay, which at that time must have covered a much wider area than now on the adjoining hills. A somewhat larger admixture of far-travelled fragments from the drift might be expected, and as a matter of fact is generally found, in all gravel deposits of the district which occur on higher and older terraces, or nearer the hills.

The portions of the Barrington Gravel, which are of the same coarseness as that of Barnwell, do not differ much from it in composition; in both cases a large proportion of the material consists of ferruginous subangular flints.

The Barrington deposit is exceptionally rich in the number and variety of its Mammalian remains. Small pieces of bone occur through the whole, but the largest and best-preserved bones lie in irregular masses of gravel near the base. In one place just above the Chalk-marl there was a boulder of quartzite about 9 inches in diameter resting upon a large limb bone. The bones are generally scattered and mixed, but occasionally there seems to be evidence of associated remains. Among the valuable specimens secured by Mr. Keeping's skill for the Woodwardian Museum, there are several whole lower jaws of Hippopotamus and a nearly perfect skull of Hyæna. It will be seen on comparing the lists of fossils given below (p. 202), that the Mammalian remains from this pit at Barrington (Column IV.) agree with those from Barnwell Abbey (Column I.), with the exception of *Arvicola*, determined by Mr. Oldfield Thomas, which has not been found at Barrington, and of Reindeer, the occurrence of which at Barnwell rests on the determination of a small fragment of antler. Horse occurs in all four localities.

Bison priscus, *Cervus megaceros*, *C. tarandus*, *Hippopotamus amphibius* (*major*), *Rhinoceros leptorhinus*, and *Meles taxus*, have not been found at Grantchester, but these diggings were unfortunately not so carefully watched as they might have been. Bones have been obtained from the pit near Barnwell Station, but they have, generally, been too fragmentary for determination. The following species have, however, been made out, Red Deer, Mammoth, Rhinoceros and Horse.

At Barrington the shells occurred in rapidly thinning and thicken-

[1] xxxv. 1879, p. 670. [2] pp. 94-5.

ing beds of loam and sand in the same manner as at Barnwell Station, but not indiscriminately through coarse gravel and finer deposits as at Barnwell Abbey.

The shells of Barnwell Station (Column III.) and Barrington (Column IV.) seem to represent marginal deposits such as are seen along the edges of ponds and rivers at the present time, occasionally encroached upon by river floods which swept them into holes and embayed corners.

This is suggested by the accumulation of the smaller and lighter shells, just as now seen on the edge of the flood-water, and by the great abundance of *Pupa marginata,* while the rest of the shells are quite consistent with this view. *Anodonta* is rare and usually imperfect.

The shells of Barnwell Abbey (Column I.) and of Grantchester (Column II.) seem to belong rather to the main channel of the river. *Unio* and *Corbicula,* which like river-beds, occur at Barnwell Abbey and Grantchester, but not at Barnwell Station or Barrington. *Pupa,* the characteristic shell of the other two localities, is comparatively rare at Barnwell Abbey and Grantchester.

There is a marked agreement between the Barnwell Abbey and Grantchester Mollusca. All the species which are individually numerous in either locality are common to both. Those which are peculiar to one of the two localities are rare forms. Thus *Hydrobia marginata,* Mich., occurs at Barnwell Abbey, but has not been found at Grantchester. *Limax* is recorded only from Barnwell. Single specimens of *Planorbis nitidus,* Müll., *P. fontanus,* Light., *Patula ruderata,* Müll., *Helix lamellata,* Jeff., *Vertigo pusilla,* Müll., *V. edentula,* Drap., *V. minutissima,* Hart., and *Cæcilianella acicula,* Müll., have been found at Barnwell Abbey and there only. On the other hand, *Planorbis nautilus,* Linn., *Helix obvoluta,* Müll., and *H. aculeata,* Müll., are as yet peculiar to Grantchester. A more careful search would, however, probably result in filling up most of the gaps in both lists (see pp. 200—202) :—

I must here acknowledge the kind help which I have received from Mr. Cooke in drawing up the list of shells, and in finding the range of various species.

I am also much indebted to Mr. Dewick for the trouble he has taken in determining my specimens of *Limax* and some other species, by comparison with those in the Natural History Museum, and also for lending me his rarer specimens for examination.

Professor Rupert Jones has kindly determined the Ostracoda for me. He remarks that he has found *Candona compressa,* Koch, in Post-Tertiary beds in Berkshire, Cambridgeshire, also at Fisherton, near Salisbury, from the raised beach of Portland (Prestwich Coll.), and from the Chara Bed near Hitchin (Blackmore Coll.). *Candona candida,* Müll., he says, is very common, both Recent and Post-Tertiary.

An explanation of the isolated or rare occurrence of certain forms in the ancient river deposits is suggested by what is seen at the present time along the Cam above Cambridge, where the artificial

List of Fossils from Gravels in the Neighbourhood of Cambridge.	Barnwell Abbey.	Grantchester.	Barnwell Station.	Barrington.
	I.	II.	III.	IV.
Plants.				
Spores and stems of *Chara*	x			
Salix (probably *S. repens*). Twigs and leaves.	x			
Invertebrata.				
Crustacea (Ostracoda).				
Cypris reptans, Baird (see Jones, Post-Tert. Entom. 1874, p. 128).	....	x		
Candona compressa, Koch (*ib.* p. 135).	x			
——— *candida* Müll. (*ib.* p. 135).	x			
Invertebrata—Mollusca.				
Lamellibranchiata.				
Sphærium corneum, Linn. (Not very large, mostly young.)	x	x	....	x
S. lacustre, Müll, York Museum	x			
Pisidium amnicum, Müll. (Very abundant. Valves adh.)	x	x	x	x
——— *fontinale*, Drap. (Abundant. Valves adherent.)	x	x	x	x
——— ——— var. *Henslowana*, Sheppard. (Abundant at Grantchester.)	x	x	....	x
——— *pusillum*, Gmel. (In Mr. Dewick's and also in Mr. Tomlin's Collection from Barnwell Abbey. Several specimens in the Woodwardian Museum from Grantchester.)	x	x		
Corbicula fluminalis, Müll. (Usually of a small size. Great variety in size, shape, texture and sculpture. Very abundant at Barnwell Abbey and Grantchester. Valves often adherent and ligament preserved.)	x	x		
Unio pictorum, Linn.	x	x		
——— ——— var. *limosa*, Nils.	x	x		
——— *litoralis*, Lamk. = *U. rhomboideus*, Schröt. (Great variation in size, shape and thickness. Both valves often adherent and ligament preserved.)	x	x		
Anodonta, sp.	....	....	....	x
Gasteropoda.				
Bythinia tentaculata, Linn. (Varies much in size. Many young specimens. Opercula very common in places. Sometimes found still in the shell.)	x	x	....	x
Hydrobia marginata, Mich. (Rare.)	x			
Valvata piscinalis, Müll. (Very abundant. Varies very much in size and shape. Many young specimens.)	x	x	x	x
——— *cristata*, Müll. (Not common.)	x	x	....	x
Planorbis nitidus, Müll. = *P. lineatus*, Walker. Very rare. (One specimen in Mr. Tomlin's Collection.)	x			
——— *fontanus*, Lightf. = *P. nitidus*, Müll. (Jeff.) British Conchology, vol. i. p. 81. Mr. Dewick has a single specimen in his Collection, from Barnwell.	x			
——— *nautilus*, Linn.	....	x		
——— *glaber*, Jeff. (Very rare.)	x	x		
——— *spirorbis*, Müll. (Common at Barnwell Junction.).	x	x	x	x
——— *vortex*, Linn. (Rare.)	x	x		
——— *carinatus*, Müll. (Rare.)	x	x?	x	
——— *complanatus*, Linn. (Fairly abundant.)	x	x		

GASTEROPODA—*continued.*	I.	II.	III.	IV.
Planorbis contortus, Linn. (Rare.)	x	x	x	
Physa hypnorum, Linn. (Single specimen from Grantchester, in the Woodwardian Museum. One specimen from Barnwell Abbey in Mr. Tomlin's Collection.)	x	x		
——— *fontinalis*, Linn. (Three or four good specimens from Barnwell Abbey in Mr. Tomlin's Collection, and one specimen from Grantchester in the Woodwardian Museum.)	x	x		
Limnæa peregra, Müll. (Not common.)	x	x	x	x
——— *auricularia*, Linn. (Very common. Spire often much intorted. Two specimens from Barnwell Abbey slightly scalariform. Varies much in size. Lines of growth often strongly marked.)	x	x		
——— *stagnalis*, Linn. (A few specimens only from Barnwell Abbey. Fairly common at Grantchester.)	x	x		
——— *palustris*, Müll.	x	x	x	x
——— *truncatula*, Müll. (Common at Grantchester. Many very small specimens.)	x	x	x	x
Ancylus fluviatilis, Müll.	x	x		
——— *lacustris*, Linn. = *oblongus*, Forbes & Hanley.	x	x		
LAND SHELLS.				
Limax agrestis, Linn.	x			
——— *arborum*, Bonch. Chant. (Mr. Dewick determined two specimens found by me.)	x			
——— *lævis*, Müll. (Two specimens found by myself.)	x			
Succinea putris, Linn. (Very large specimens at Barnwell Abbey and Grantchester.)	x	x	x	x
——— *elegans*, Risso.	x	x	x	x
——— *oblonga*, Drap.	x	x	x	
Hyalina cellaria, Müll.	x	x		
——— *nitidula*, Drap.	x	x		
——— *radiatula*, Alder.	x	x		
——— *nitida*, Müll.	x	x		
——— *crystallina*, Müll.	x	x		
Conulus fulvus, Drap.	x	x		
Patula rotundata, Müll. (Rare.)	x	x		
——— *ruderata*, Studer. (A single specimen found by Mr. Dewick.)	x			
——— *pygmæa*, Drap. (One reversed specimen found at Barnwell Abbey by Mr. Dewick.)	x	x		
Helix (*Anchistoma*) *obvoluta*, Müll. (One full grown and one young specimen in the Woodwardian Museum.)	.....	x		
——— (*Acanthinula*) *aculeata*, Müll. (Twelve specimens in the Woodwardian Museum.)	.....	x		
——— (———) *lamellata*, Jeff. (A single specimen found by Mr. Dewick.)	x			
——— (*Vallonia*) *pulchella*, Müll. (Very abundant.)	x	x	....	x
——— (*Fruticicola*) *hispida*, Linn.	x	x	x	x
——— (———) *concinna*, Jeff. (One reversed specimen found at Barnwell Abbey by Mr. Dewick.)	x	x	x	x
——— (———) *fruticum*, Müll. (Rare.)	x	x		
——— (*Chilotrema*) *lapicida*, Linn. (Three specimens from Barnwell Abbey. One in Mr. Dewick's Collection and two in the Woodwardian Museum. Two specimens from Grantchester in the Woodwardian Museum.)	x	x		
——— (*Arionta*) *arbustorum*, Linn. (Varies very much. Many of the shells distorted and injured.)	x	x		
——— (———) var. *alpestris*, Ziegler. (Common at Barnwell Abbey.)	x	x		

List of Fossils from Gravels in the Neighbourhood of Cambridge—*continued.*	Barnwell Abbey.	Grantchester.	Barnwell Station.	Barrington.
	I.	II.	III.	IV.
Helix (*Tachea*) *nemoralis*, Linn. [Not very common. Varieties of banding, 12345, 00345, (12345), 1(23)45, 00330, 003(45), 10345.]	x	x	.....	x
——— (*Xerophila*) *cricetorum*, Müll. (Common at Barnwell Abbey and Grantchester.)	x	x	x	x
——— (———) *virgata*, DaC. (Common at Barrington.)	.....	.....	.....	x
——— (———) *caperata*, Mont. (Very rare.)	x	x	.....	?
Buliminus montanus, Drap.	x	x	x	
——— *obscurus*, Müll. (One specimen from Barnwell Abbey in the York Museum, and one from Grantchester in the Woodwardian Museum.)	x	x		
Pupa marginata, Drap. (Very abundant at Barnwell Station and at Barrington.)	x	x	x	x
Vertigo antivertigo, Drap.	x	x		
——— *Moulinsiana*, Dupuy.	x	x		
——— *pusilla*, Müll. (One in Mr. Tomlin's Coll.)	x			
——— *angustior*, Jeff.	x	x		
——— *pygmæa*, Drap.	x	x		
——— *edentula*, Drap. (One found by Mr. Dewick resembles var. *columella* of Jeffreys.)	x			
——— *minutissima*, Hartmann. (One specimen found by Mr Dewick.)	x			
Balea perversa ? Linn. Young. Mr. Dewick's Coll.	x			
Clausilia rugosa, Drap.	x	x		
——— *pumila*, Ziegler. (Described in former lists as *C. biplicata*.)	x	x		
Azeca tridens, Riet. (Rare.)	x	x		
Zua lubrica, Müll.	x	x	x	x
Cæcilianella acicula, Müll. (One specimen found by Mr. Dewick. Young. Filled with gravel.)	x	x		
Carychium minimum, Müll. (Common. Several of the specimens found inside *H. arbustorum* and *H. nemoralis*.)	x	x		
Cyclostoma elegans, Müll. (One specimen only, found by me in the Mammaliferous gravel of Barrington.)	.....	.....	.....	x
Vertebrata.				
Bison priscus, Bojan.	x	.....	.....	x
Bos primigenius, Bojan.	x	x	.....	x
Cervus megaceros, Hart.	x	.....	.....	x
——— *elaphus*, Linn.	x	x	x	x
——— *tarandus*, Linn.	x			
Elephas antiquus, Falc.	x	?	.....	x
——— *primigenius*, Blum.	x	x	x	x
Equus caballus fossilis, Meyer.	x	x	x	x
Felis spelæa, Goldf.	x	x	.....	x
Hippopotamus amphibius, L. = *major*, Cuv.	x	.....	.....	x
Hyæna crocuta = *spelæa*, Goldf.	x	x	.....	x
Rhinoceros leptorhinus, or *tichorhinus*, Cuvier.	x	.....	x	x
Ursus spelæus, Blum.	x	x	.....	x
Meles taxus, Owen.	x	.....	.....	x
Arvicola agrestis ? sp.	x	x		

diversion of the river has produced effects which must have been common in the case of the uncontrolled rivers of former times. On Sheep's Green there are many small ponds which represent deserted portions of the old river-bed; in these many of the less common and irregularly distributed freshwater shells occur—abundantly in one—rarely, or not at all, in another. For instance, we find *Bythinia Leachii* there, as well as in the ditches further south. In one of the ponds seven species of *Planorbis*, including the two rare forms *P. nitidus*, Müll., and *P. fontanus*, Light., also *Valvata cristata*, Müll., and many of the *Pisidia*, are found.

Mr. Tomlin, who has thoroughly searched that locality, informs me that two of the ponds are far richer than any of the others, and that he never met with the two rare species of *Planorbis*, mentioned above, elsewhere in this neighbourhood, except odd live specimens in some of the other Sheep's Green ponds. He never found them anywhere down the river.

Along the margin of these pools *Carychium minimum*, Müll., and *Hyalina nitida*, Müll., abound. Now and then, when the river is in flood, the whole Green is under water, and at such times many of the shells in these ponds and ditches must be carried away and mixed with the common river shells.

From analogy, therefore, it would appear that the winding about of a frequently flooded river, over an alluvial plain, in which ponds remained where the deeper parts of the old river-bed had been, would most easily account for the difference in the facies of the gravel-shells in the different localities.

A careful study of the distribution and mode of occurrence of the gravel fauna and flora ought to give us some clue to the geographical changes which have affected the incoming and disappearance of the various forms of life.

The great majority of Mollusca from these gravels are living in this district at the present day. A few are locally extinct. Of these some are confined to the north and some to the south of England, whilst some have disappeared from the British Isles altogether. Some of the Mammals, but none of the Mollusca, are totally extinct.

The shell which seems to indicate the greatest change of conditions is the *Corbicula* (*Cyrena*) *fluminalis*, Müll.

It lives at the present time in Sicily,[1] in the rivers of Asia Minor and Syria and in the Nile. It seems to have made its first appearance in Britain in the time of the deposition of the Norwich Crag, from which it is described and figured by Mr. Searles Wood,[2] as *Cyrena consobrina*.[3]

It is recorded from the Weybourn Crag and from the Forest Bed. In the north of England it is found in the gravels of the Humber, of Kelsea Hill, and Hessle; in the basin of the Thames and the adjoining district of Essex it has been recorded from Suttonness, Clacton-on-Sea, Copford, Greys, Ilford, Erith, and Crayford, Faver-

[1] Geol. Eng. and Wales, H. B. Woodward, 2nd edition, p. 478.
[2] S. V. Wood, "The Crag Mollusca," vol. ii. p. 104, tab. 11, fig. 15.
[3] Tylor, Q.J.G.S. vol. xxv. 1869, p. 66.

sham and Reculvers, and by Prof. Prestwich[1] from Summertown near Oxford. It also occurs in the gravels of the basin of the Cam and Ouse. It occurs in Belgium and in France in the ancient alluvium of the Seine and Somme. This therefore appears to be a southern shell, which had formerly a more northern range.

The six following shells are extinct in Britain, but most of them have a wide range in Europe and Asia:—

Unio litoralis, Lamk., is, according to Moquin Tandon,[2] found in almost all the rivers of France. Kobelt records it also from Spain, Morocco, and Algeria.

Unio pictorum, var. *limosa*, Nils., according to Moquin Tandon, occurs in almost all the rivers and brooks of Northern France.

Hydrobia marginata, Mich., lives in France, says the same author, on dead leaves under water and on aquatic plants at Var, Vaucluse, L'Aveyron, the Haute Garonne and the Jura.

Helix (*Fruticicola*) *fruticum*, Müll., is found all over Europe with the one exception of England. It ranges as far north as St. Petersburg.[3] Moquin Tandon[4] says that it is found over almost all northern and central France, but that it does not occur in the southern part.

Miss Esmark records it from North and South Norway, Sweden, and Finland. She says, "It is not very common, but plentiful where it occurs."[5] I am told by Mr. Cooke that it occurs also in North-West and East Siberia and the Altai Baikal district.

Patula ruderata, Studer, has a very wide range. Kobelt records it from the Caucasus, Europe, Northern Africa, and the whole of Western Asia. Jeffreys from Kamschatka, South Russia and Austria, and North Japan.[6] Clessin says that it lives in the mountainous parts of Germany and in the Alps. Moquin Tandon says it is found under stones and dead leaves in the Jura. Miss Esmark records it from Norway, Sweden, and Finland, and remarks that it is "one of our most common species, which goes as well to the far north as on our highest mountains, wherever it is possible for any Molluscs to live."[7] Mr. Cooke infotms me that it is found also in West and East Siberia, Amurland, North China, Japan ? and North Persia.

Clausilia pumila, Ziegler, is, according to Clessin,[8] distributed over a great part of Germany, but is most common in the North. Its range is eastward to the Siebenbürgen; southward to Croatia; northward to Livland and Sweden; it finds its western limit in Germany, and does not occur in England except as a fossil.

It has hitherto been recorded from the gravels of Cambridge as *C. biplicata*, but Mr. B. B. Woodward[9] has shown that all the shells referred to that species are really the *C. pumila* of Ziegler.

[1] Geol. Mag. n.s. Vol. IX. 1882, p. 49. [2] Hist. Nat. des Mollusques.
[3] Clessin, Deutsche. Excurs. Mollusken-Fauna, p. 166.
[4] *Op. cit.* vol. ii. p. 198. [5] Esmark, Journ. Conch. vol. v. pp. 106, 126.
[6] Jeff. Brit. Conch. vol. v. Supplement, p. 158.
[7] Journ. Conch, vol. v. p. 104. [8] *Op. cit.* p. 312.
[9] Since this paper was sent to press a valuable communication has been made by Mr. Woodward to the Geol. Assoc. (March 2, 1888) on the shells of the Barnwell Gravel, founded chiefly on Mr. Dewick's Collection. *Sphærium lacustre* has been inserted above on his authority.

There are also in the gravels described some six or eight shells which we do not now find in the neighbourhood of Cambridge, but which occur elsewhere in the British Isles.

Succinea oblonga, Drap., is mentioned by Gwyn-Jeffreys[1] as rare in Wales, Scotland and Ireland and in England is recorded from Braunton Burrows in Devonshire only. Its habitat is "dry ditches near the sea-coast."

Helix (*Anchistoma*) *obvoluta*, Müll. This shell, says Jeffreys, lives on stumps and at the roots of trees in woods in Hampshire. Da Costa and Taylor give it a somewhat wider range in the south of England, mentioning also Surrey and West Sussex.

Jeffreys observes that it occurs in France, Germany, Switzerland, and Lombardy, but that it does not seem to inhabit the extreme north and south of Europe.[2]

Clessin says that it is less common in the north than in the south of Germany, and he records it also from Bohemia.[3] This occurrence of *H. obvoluta* in the gravels shows that it is not a form now advancing from the south, but is, on the contrary, a species which is dying out in England, but still survives in the south.

Helix (*Acanthinula*) *lamellata*, Jeff., is now found only in the north of England, Anglesey, north and west of Scotland, Ireland, Sweden. Clessin[4] records it from North Germany. In this shell we have, in contrast to the last-mentioned species, an example of a form which has become extinct in the south of England, but is still fairly plentiful in the north.

Vertigo angustior, Jeff. The habitat of this rare shell is "in the roots of grass in marshy ground." Jeffreys found it near Swansea and in the rejectamenta of the river Avon at Bristol. He records it from Tenby, Battersea Fields, and Ireland, the north-east and south of France, Germany, Switzerland, and from Lugano in Italy.[5]

Mr. Charles Ashford, who kindly examined a specimen which I had discovered at Barnwell, found on comparing it with recent *Vertigo pusilla* in his collection from Yorkshire, that amongst them was one undoubted *Vertigo angustior* which he had hitherto overlooked. I have found it in Westmoreland also. Miss Esmark records it from South Norway and Sweden.[6]

Possibly the following species did not appear in England till after the deposition of these gravels.

Helix (*Fruticicola*) *cantiana*, Mont., does not seem to occur in the gravels. It is very common round Cambridge at the present time, and is found in the north and south of England, but not in Scotland or Ireland. It lives in France, Belgium, parts of Germany, Italy, Illyria, and Sicily.

It is doubtful whether *Helix* (*Fruticicola*) *rufescens*, Pennant, is found in the gravels. It is now widely distributed over England, and occurs in Ireland, but not in Scotland.

Helix aspersa, Müll., is not recorded from any of the localities

[1] Brit. Conch. vol. i. p. 154.
[2] *Op. cit.* p. 230.
[3] Deutsch. Exc. Moll.-Fauna, p. 134.
[4] *Op. cit.* p. 129.
[5] Brit. Conch. vol. i. p. 266.
[6] Journ. Conch. vol. v. p. 127.

given in the list, nor can I find mention of it from similar gravels elsewhere.

Mr. Gloyne in his paper on the Geographical Distribution of the Mollusca,[1] says, "*Helix aspersa* attains a much larger size in Italy than in England. It is very difficult to believe that so abundant a British species has been introduced; but judging from the reduced size of English specimens, England would, to say the least, not appear to possess the most favourable climate for this mollusc."

Jeffreys says, "It does not appear to inhabit the north of Europe, nor Germany . . . but its range extends southwards through France to Sicily, as well as to Spain, Algeria, and the Azores.[2]

It occurs also in many widely separated parts of the world to which it is known to have been artificially introduced. As, for instance, Mauritius, S. Australia, Valparaiso, Rio in Brazil, and sea-ports along the east coast of N. America. The only evidence we have bearing upon the time of its first appearance in Britain is its plentiful occurrence in the Roman rubbish pits at Chesterford and elsewhere about Cambridge at such a depth and in such a manner as to preclude the possibility of its having got in subsequently.[3]

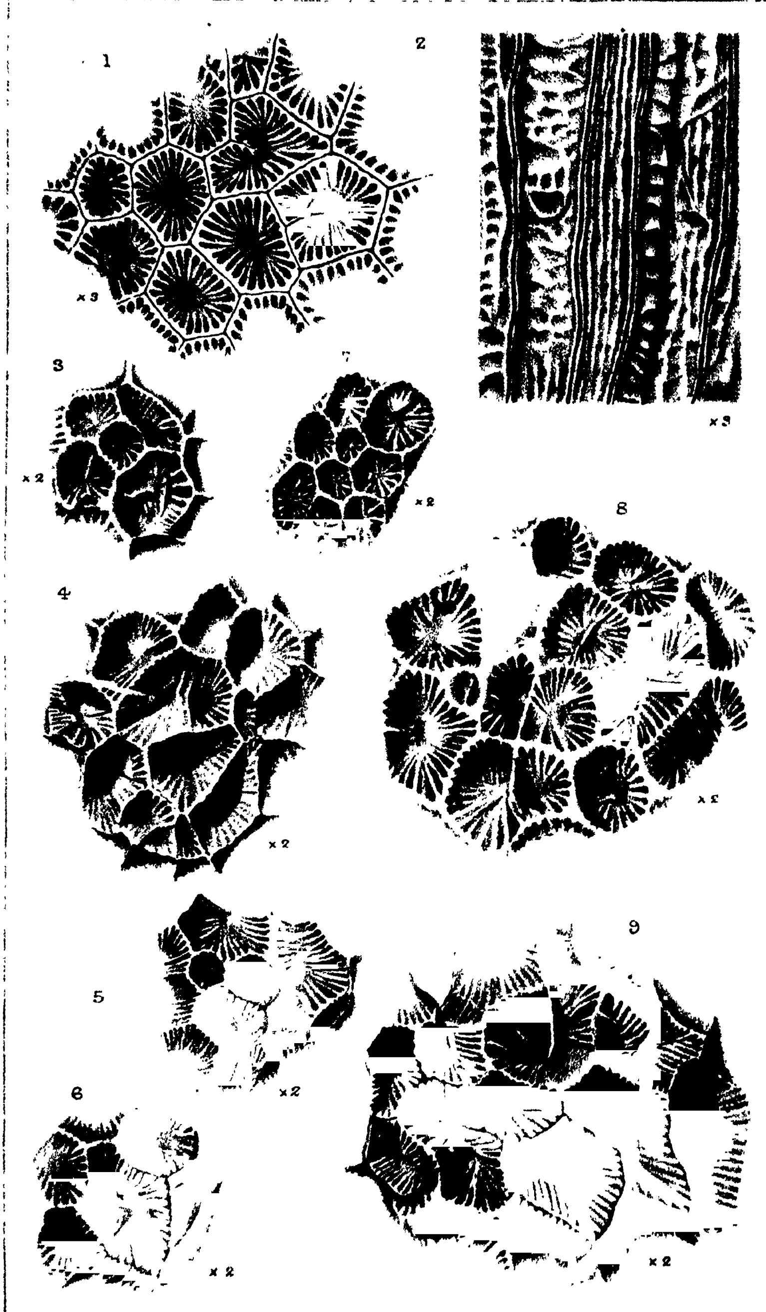
Helix ? pomatia, Linn., which lives now in the neighbourhood of Shelford, has not been found in any of these gravels, and I have never noticed it among the Roman remains of this district, even where shells of *H. aspersa* appear to have been thrown in in large quantities.

Helix (*Arionta*) *arbustorum*, Linn., is now found with *Helix* (*Tachea*) *nemoralis* in the Grantchester woods. It also lives under the willows close to the river, and is seldom found far from the water. A few days ago I noticed numbers of shells of this snail freshly broken by birds lying round the stones on which they had been smashed, all along the bank of the ditch near the bathing sheds on Coe Fen. This species is extremely common in the gravels of Barnwell Abbey and Grantchester. It probably found a hiding-place as at present under willows, of which remains, as we have seen above, occurred so abundantly in one part of the pit at Barnwell Abbey.

Cyclostoma elegans, Müll. I have found one specimen of this shell undoubtedly in the Mammalian gravel of Barrington. It does not now live in the immediate neighbourhood of Cambridge. I found quantities of dead shells, many with the opercula in place, several feet from the surface, in a tumulus of pre-Roman date, at Upper Hare Park, near Six Mile Bottom.

It appears, therefore (see pp. 203—204) that among the shells of the Cambridge gravels we have no fewer than 6 species which are no longer found in Britain. Several species which I have mentioned (see p. 205) have been found in the gravels, but have now disappeared from this district, though they occur in other parts of England, and some species which are common near Cambridge at the present time are absent from the gravels (see p. 205).

[1] Journ. Conch. vol. i. p. 289. [2] Brit. Conch. vol. i. p. 182.
[3] See also B. B. Woodward, Science Gossip, May, 1883, pp. 115, 237.



F. C. Knight del. et lith. West, Newman & Co. imp.

It will be seen, also, that of the locally extinct Mollusca, as in the case of the Mammalia, some are distinctly northern, some southern forms, and some have an extensive range from north to south. Considering the wide distribution of the forms, both extinct and living, it is not safe, without taking into account the habitat and range of every species, to generalize upon the climatal conditions of the age. The collective evidence which we gain from the Mollusca as to the climate of the period is more reliable than that offered by the Mammalia, because the various northern and southern Mammals could migrate to and fro with the changing seasons; but the molluscs once having found their way to a locality would remain there until they were slowly driven away by unfavourable conditions. The two shells of most pronounced southern origin, *Corbicula fluminalis* and *Unio litoralis*, being fresh-water forms, would not be affected by changes of temperature so soon as land-shells.

With regard to geographical changes, the whole gravel fauna seems to point to continental conditions, when Europe was connected with Africa, and England was united with France and Belgium. The formation of the British Channel would put an end to the migration of the larger animals, and would cut off the species, which had here reached their furthest limit, from the region of their greatest development. These species, being thus isolated, would in time give way to the more vigorous forms, which were better fitted to their surroundings, and would not be affected by such changes.

II.—On *Heterastræa*, a new Genus of Madreporaria from the Lower Lias.

By Robert F. Tomes, Esq.

(PLATE VII.)

During the interval of ten years which has elapsed since my paper on Liassic Madreporaria was read at one of the meetings of the Geological Society, a great many specimens of Liassic *Isastrææ* and *Septastrææ*, chiefly from the Vale of Evesham, have come into my hands, and with this abundance of material I have examined anew the several species, and have arrived at the results contained in the present communication.[1] When making these examinations, I have been invariably struck with the absence of a distinct and well-defined basal wall and epitheca. Further observation also showed that these Liassic forms differed from other *Isastrææ* in having occasional elongated calices, like those of *Latimæandra*. With the latter genus some of the Liassic *Isastrææ* were supposed (though as it now appears erroneously) to hold a near relationship, and one species received the (at that time) appropriate specific name *latimæandroidea*. With this the supposed resemblance ended; for gemmation, which in *Latimæandra* is calicinal, was found to be always marginal in the Liassic forms.[2] Fuller investigation brought to

[1] More than seventy specimens have been examined and contributed to the results made known in this paper.

[2] It has become necessary that gemmation in the genus *Isastræa* should receive further attention. It has been variously stated both by Prof. Duncan and by me to

light other characters. A great development of endothecal structure sometimes almost filled up the loculi, and the walls of the corallites were observed to be of great thickness. Horizontal sections gave the proper interpretation of these thickened walls, and it was often seen that there was not only a fine line where the walls of the corallites came in contact, but that there was occasionally a visible interval between them. In this particular they resembled *Septastræa*, while at the same time their increase was by gemmation. Closer observation revealed the fact that there was both gemmation and fissiparity in nearly all the species examined; and, in a word, that they possessed characters which were inconsistent with both *Isastræa* and *Septastræa*, and formed a group of themselves.

Before proceeding to define the characters of the group above indicated, I take the opportunity of making some remarks which bear, though only generally, on the species under consideration.

Having repeatedly, both on former occasions and in the present communication, followed Milaschewitsch in the use of a word which is rendered in English by the word rejuvenescence, I am induced to give the following explanation of the process, because it is absolutely necessary that there should be a very clear conception of its importance in one of the genera of which I shall speak. That genus is *Elysastræa*. That it is not merely intermittent growth, and that it is not gemmation, has been most clearly shown by Milaschewitsch, but what really gives rise to it has not been explained by him. It was certainly noticed by Ehrenberg, and was long ago known to Dana, though he does not appear to have fully understood its nature. In the third volume of the American Journal of Science (second series) he speaks as follows:—

"In some Cyathophyllidæ the process of death goes on interruptedly, as explained by Ehrenberg. The tissues of the polyp disappear at intervals from the sides of the corallum, or become dead, leaving a row of unoccupied cellules; then the animal goes on to increase from its contracted size, without refilling the cellules; the corallum consequently becomes covered with encircling ridges, or appears as if formed of a series of inverted cones. In some cases, as in the species referred to the genus *Strombodes*, the living portion becomes retracted at intervals to the very centre, all the rest dying, and afterwards the animal grows again and spreads to its original

take place within the calice, as well as on the margin of the wall which surrounds it. Thus in the descriptions of *Isastræa endothecata* and *I. latimæandroidea*, Prof. Duncan says it is marginal ("on the margin" are the words made use of in the description of the latter species). More recently, however, he has asserted that "the gemmation of *Isastræa* certainly does not take place between the walls of corallites, but within the calicular margin; it is between the margin and the centre of the calice." I am not aware that it has ever been spoken of as occurring between the walls, though I, as well as Prof. Duncan himself, have spoken of it as occurring both *inside the calice and on the margin of the wall.* MM. Milne Edwards and Haime (Hist. Nat. Coral. vol. ii. p. 526) speak of it in these words, "Les polypierites se multiplient par gemmation calicinale et submarginale," while M. de Fromentel says it is "submarginale." The present communication by removing the Liassic species from the genus *Isastræa* altogether, will materially lessen the difficulty of future classification.

diameter, and thus it forms actually one low inverted cone upon another. This peculiarity (probably an occasional result of the exhaustion which follows reproduction) cannot properly be considered a generic distinction."

In his "Structure and Classification of Zoophytes," page 65, after speaking of the process of dying or removal below, he says, "It is obvious from the preceding, that the polyp, which is the germ of a compound Zoophyte, loses its identity, and cannot be said, in any proper sense, to have the long life which is attributed to the full grown Zoophyte itself; or else we might have among the huge Astræas of the Red Sea, polyps that were contemporaries with the builders of the Pyramids." The polyp, however, "which is the germ of a compound Zoophyte," may lose its identity, and most likely does, by the process of gemmation, but not by rejuvenescence, which under no circumstances, as explained by Milaschewitsch, increases the number of corallites, and it is certainly rejuvenescence, of which Dana was then speaking.

It is when the contraction of the polyp takes place very irregularly, that the true nature of the process becomes most easily determined. If the shrinking of the soft tissues of the polyp is wholly on one side, and very great in degree, so that the visceral cavity is drawn out of the centre of the calice, then the constricted side of the animal will be lifted out of the loculi in the process, but that side which has undergone no such contraction may be very little interfered with. In such a case entirely new septa will be formed on one side of the now-expanding calice, while on the other side, no new ones will be produced, nor indeed needed, the old ones being still in actual use. The contraction may, however, be, and it often is, just sufficient to leave vacant only those loculi which have been formed by the later developed septa, and then there will be the full number of cycles on one side, while on the other the primary septa only will be present.

As observed by Dana, rejuvenescence is not of generic importance, and he might have said that it had no specific value, in which respect it differs widely from gemmation, which has not only specific but great generic value.

The Madreporaria of the Trias are very little known in this country, and beyond a few species which occur in the Sutton Stone of the Glamorganshire coast, we have to refer chiefly to Laube's descriptions and figures of the St. Cassian species. An examination of the compound genus *Elysastræa* reveals a very curious septal arrangement. This I will now proceed to consider, and it will be desirable that I should, in the first place, quote from Laube some part of his generic description. He says that gemmation takes place within the calice, and resembles that of *Heliastræa*.[1] He then goes on to state that the young individual separates itself by a little

[1] MM. Milne Edwards and Haime define the budding in *Heliastræa* in the following words: "Les nouveaux individus produits par bourgèonnement se montrent dans les differents espaces intercalicinaux." Probably gemmation in *Elysastræa* also took place in the intercalicular spaces.

wall by which the calice acquires the appearance as if a double wall were present, as in the Palæozoic genus *Acervularia*. By degrees the margin extends itself, until it blends with the thick surrounding margin of the older calice. Laube's figure illustrates the process above described. But both description and figures will apply with greater accuracy to rejuvenescence than to calicinal budding, which process in *Acervularia*, to which that of *Elysastræa* has been likened by Laube, is a process of multiplication, and in neither his description nor in the figure is there the slightest indication of an increase in the number of the corallites by calicinal budding. On the contrary, there are many small calices appearing amongst the larger ones, just as they would appear were they the result of marginal instead of calicinal gemmation.

Prof. Duncan, in describing the South Wales *Elysastrææ*, says that the budding is extracalicular, but that the bud probably has its origin in the centre of a corallite. No evidence is however adduced in favour of the latter supposition. None of my specimens from the Sutton Stone exhibit the budding process as it is shown in Prof. Duncan's figures, *i.e.* between the corallites; but they have rejuvenescence just as in Laube's figure. The young calices between the old ones in Prof. Duncan's figures are just such as would proceed from marginal gemmation in a genus in which the corallites are imperfectly united by their walls, and I have little doubt but that gemmation in *Elysastræa* is marginal, as it is in the so-called Liassic *Isastrææ*.

The nature of the endotheca in the South Wales *Elysastræa* is very apparent and closely resembles that of the forms which I now bring together under the name of *Heterastræa*, in all of which, I may here observe, it is so very similar, that I do not find that it affords even so much as a specific difference. Vertical sections show how very similar it is in the several species.

There are some of the species which have occasional calices which are almost as free on the calicular surface of the corallum as those of *Elysastræa*. *Isastræa Murchisoni* is one of these, and, as mentioned by Prof. Duncan, some of the corallites are so much elevated above the others that there is "a faint trace of a subsequent growth of wall," by which I presume it is meant that there is an addition made to the wall after it has been formed. As will be hereafter mentioned when speaking of the species, there is also rejuvenescence in *Isastræa Murchisoni*, as there is in *Elysastræa*.

Bearing in mind all the foregoing considerations, I have arrived at the conclusion that there is a rather near relationship between the Triassic genus *Elysastræa* and the so-called Liassic *Isastræa* and *Septastræa*, and that the latter are one and the same generically, and quite distinct from the later Secondary *Isastrææ* and the Tertiary *Septastrææ*. The genus into which I now propose to place the following species, I name and define as follows:—

HETERASTRÆA, nov. gen.

The corallum is composite and massive, and the corallites are

united by their walls, but the union is often incomplete, and the line of contact frequently visible.

There is an occasional trace of a common or basal wall, with a rudimentary pellicular epitheca, both of which, however, are very often wanting.

The endotheca consists of dissepiments which are not vesicular, but flat and more or less tabular, and there are occasionally distinct tabulæ, many of them passing quite across from wall to wall of the corallite, forming a level floor to the calice.

Increase takes place by gemmation, which is strictly marginal, and never calicinal, and by fissiparity, which is first indicated by the elongation of the dividing calices, followed by the appearance of two or more fossulæ, which are finally divided from each other by the union of two elongated septa.[1]

The prevalence of gemmation over fissiparity, or the reverse, exercises a decided influence, not only over the shape of the calices, but also to some extent over the general contour of the corallum. The elevation of budding calices above the level of the surrounding ones tends to produce a more gibbous surface than does the division of the calices by fission, and the conformation of the corallum is modified accordingly. This will be further noticed when I speak of the species, which I shall now proceed to do, first enumerating those which I have not had the opportunity of examining. They are:—*Isastræa intermedia*, De Ferry; *I. excavata*, De Ferry; *I. basaltiformis*, Fromentel; *I. Orbignyi*, Chap. et Dewal.; *I. Condeana*, Chap. et Dewal.; *I. Moreneyana*, Terq. et Piette; *I.* ? *Henacquei*, Ed. et Haime; and *Latimæandra denticulata*, Duncan, all of which have been stated to occur in the Lower Lias.

HETERASTRÆA MURCHISONI, Wright sp.

Isastræa Murchisoni, Dunc., Supp. Brit. Foss. Cor. pt. iv. p. 41, pl. xi. figs. 1–4.

The only example of this remarkable species, from the Isle of Skye, to which I have access, is small in size, and has but little calicular surface. Yet, small as it is, it has marginal gemmation, and elongated calices which, having more than one fossula, with an indication of dividing septa between them, affords indubitable evidence of fissiparity. Prof. Duncan says, "There is often a ridge between the margin of the calice and the centre, indicating calicinal gemmation, but the gemmation usually takes place at the margin, and there is no fissiparity." The ridge here mentioned has nothing to do with gemmation, but is merely the commencement of rejuvenescence, and in one calice of my specimen it has proceeded so far as

[1] It is necessary to notice here a variation in the process of splitting that takes place in different calices, or even in the same calice. The two opposite and approaching septa do not always meet and make the division until a new calice has been actually formed, and it is common for two or three fossulæ to make their appearance in a long calice with only some, or even without any, dividing septa. When this is the case, there is some resemblance to *Latimæandra*. However, the septa always become elongated sooner or later, and fissiparity is then complete. M. de Fromentel gives a good account of the process in his description of the so-called *Septastræa excavata*.

to have given rise to a smaller calice within the larger one, which has a considerable degree of prominence, and bears an extremely close resemblance to some of the corallites represented in the upper part of Laube's figure of *Elysastræa Fischeri.*

I have met with two ill-preserved specimens of a coral which resembles this species in the size and openness of the calices, the one from a gravel-pit at Charlton, near Evesham, and the other from the zone of *Ammonites angulatus*, near the village of Church Lench, a few miles north-west of Evesham.

HETERASTRÆA EVESHAMI, Dunc. sp. Pl. VII. Fig. 3.

Septastræa Eveshami, Dunc., Supp. Brit. Foss. Cor. pt. iv. p. 52, pl. xiii. figs. 5–7.

By the kindness of my friend the Rev. P. B. Brodie, the type-specimen of this species is now before me. The calices, which are in process of division, or have already undergone that operation, are conspicuous over the whole upper surface of the corallum, but gemmation, though apparent and marginal, is not frequent; nor is it common, though well marked, in other specimens of this species in my collection.

It is a distinct species, and in some examples the specific characters are even more typically developed than in the type itself. They are all more or less flabelliform, but they present every degree of inclination from a nearly vertical to a horizontal position. The finest specimen yet met with has the form of a regularly oval plate, ten inches long, and not more than an inch in thickness. It was attached by a broad space near one end of the under side, which is flat. The calicular surface is horizontal. Fissiparity occurs over the whole of the latter part, but gemmation is by no means common, though, where it appears, it is unmistakeable. This specimen was taken from a quarry near to Prior's Cleeve, about five miles north-east of Evesham, and its place in the Liassic beds will be best explained by the following section :—

		Ft.	Ins.
1	Surface soil with pebbles, about	2	0
2	Light-coloured clays	11	6
3	Black laminated shale with fragments of shells and Echinoderms, and a specimen of *Heterastræa Eveshami*	3	6
4	Indurated dark grey shale	0	3
5	Laminated stone with *Ammonites planorbis* and insect remains ...	0	6
6	Laminated shale	3	3
7	Laminated stone	0	7
8	Laminated shale, the upper and lower parts of which are light in colour, and the middle black. The latter is a mud deposit and contains the joints of *Pentacrinites*, *Cidaris* spines, and comminuted shells.	3	3
9	Laminated stone, with *Am. planorbis*	0	3
10	Laminated shale	0	7
11	Laminated stone	0	6
		26	2
12	Laminated shale, beneath which is the *Ostræa* bed, depth not ascertained.		

I have also obtained the present species from Binton, about four or five miles west of Stratford-on-Avon, where it was associated with *Ammonites angulatus.*

HETERASTRÆA FROMENTELI, Terq. et Piette sp. Pl. VII. Fig. 4.

Septastræa Fromenteli, Terq. et Piette, Lias Inf. de l'Est de la France, etc.
——— ———, Duncan, Supp. Brit. Foss. Corr. pt. iv. p. 37, pl. xi. fig. 5.

The example of a supposed *Septastræa* which was found in the railway cutting at Harbury, and mentioned by Prof. Duncan, as above, has been submitted to me by my friend Mr. Brodie, in whose collection it is, and a comparison has been made between it and other allied species. Two contiguous calices of this specimen are very remarkable, for on the margin of one there is gemmation, while the other is divided in half by the process of fissiparity. In no other species, or specimen, have I seen the two processes so closely associated or so obvious. Fissiparity is however much more frequent than gemmation in this specimen.

As I have only had the opportunity of examining English specimens of this species, my observations must be understood to apply to them exclusively, though I have no doubt that the French and English specimens are of one species.

HETERASTRÆA STRICKLANDI, Dunc., sp. Pl. VII. Fig. 8.

Isastræa Stricklandi, Dunc., Supp. Brit. Fos. Cor. pt. iv. p. 54, pl. viii. figs. 1-4.

The type-specimen of this species was obtained by Mr. Strickland from the clay-pit of the Chadbury brickyard, from which excavation a considerable number of specimens of so-called *Isastrææ* and *Septastrææ* were taken, some of which agree very closely with the description of this species by Prof. Duncan. I have not, however, been able to examine the type-specimen. It does not appear to be a very abundant species, only three having come into my hands. Two of them came also from the Chadbury clay-pit, and the other was dug up by a market gardener when trenching his land on the side of the hill north of Evesham on which the battle of Evesham was fought. This species is distinguished, as pointed out by the original describer, by its stout septa and thick walls. The calices are rather shallow. There is no instance in either of my specimens of budding actually taking place, though there are calices which from their circular form and their position amongst other calices have certainly proceeded from marginal budding. Fissiparity is common, and sometimes occurs rather peculiarly. The division of a calice takes place all round it, and a very large lobular calice is the consequence, and when the dividing septa make their appearance, they have a somewhat radiate arrangement.

HETERASTRÆA INSIGNIS, Dunc., sp.

Isastræa insignis, Dunc., Supp. Brit. Foss. Corr. pt. iv. p. 54, pl. xiii. figs. 10, 11.

The specimen on which Prof. Duncan established this species was obtained by me from the Lower Lias at Lyme Regis, but as the opportunity of making an examination of it since it has become a type has not occurred to me, I am compelled to fall back upon the other specimens from the same locality, of the specific identity of which, however, I entertain no doubt. Several similar specimens came into my hands with the one I lent to Prof. Duncan. These I

still have, and they have been referred to on the present occasion. They are without doubt referable to the same genus as the other species herein mentioned.

HETERASTRÆA ENDOTHECATA, Dunc. sp. Pl. VII. Fig. 9.

Isastræa endothecata, Duncan, Supp. Brit. Fos. Cor. pt. iv. p. 58, pl. xii. figs. 17-21.

Of this species the original describer says "the marginal gemmation is frequent." The figured specimen is now before me, and I observe a considerable number of calices which are elongated and have more than one fossula, as well as marginal gemmation, which is common. The irregularity in the size and form of the calices is due to the operation of these two processes proceeding at the same time. Besides the type-specimen, I have some others taken from the *Ammonites angulatus* beds of the Lower Lias, about a mile west of Evesham. These examples have a very distinct line where the corallites come together, indicating imperfect union.

HETERASTRÆA HAIMEI, Wright sp.

Septastræa Haimei, Duncan, Supp. Brit. Fos. Cor. pt. iv. p. 5, pl. i. figs. 1-5.

In 1860, when my late friend Dr. Wright was engaged in investigating the Ammonite zones of the Lower Lias, he obtained an *Isastræa* from the *Ammonites planorbis* beds of Street, and it was mentioned under the name of *Isastræa Murchisoni*, at pages 390 and 397 of the paper which followed his investigations. The specimen was for some time in my hands, and was afterwards described and figured by Prof. Duncan under the name of *Isastræa latimæandroidea*. At this time an *Isastræa*, said to have been obtained from Evesham, also formed part of Dr. Wright's Collection, but no mention was then made of it by him, though afterwards, in one of the volumes of the Palæontographical Society, it was mentioned as *Isastræa Haimei*, and as I then believed, and still believe, was erroneously stated to have been also obtained from the *Ammonites planorbis* beds of Street. Instead, however, of its appertaining to that Ammonite zone, I entertain no doubt whatever that it is referable to the *Ammonites angulatus* beds of the neighbourhood of Evesham.

Prof. Duncan subsequently described and figured it as *Isastræa Haimei*. As I have not recently had the opportunity of examining the type-specimen, I cannot speak decisively of its generic relationship, though I do not doubt that it is a species of *Heterastræa*.

HETERASTRÆA TOMESI, Duncan sp. Pl. VII. Figs. 5, 6.

Isastræa Tomesi, Duncan, Supp. Brit. Fos. Cor. pt. iv. p. 46, pl. xv. fig. 20.

The type of this species is so indifferently preserved that were it not a well-marked species it would be practically useless for comparison. But the very thin walls and septa which are apparent, whatever may be the condition of the specimen, will at once distinguish it. As a species it is not by any means uncommon; and I have seen specimens from several localities in the neighbourhood of Evesham, in addition to Grafton, where the type was obtained. It

is a low expanding form, sometimes attaining to a great size. The largest I have yet seen is almost as heavy as a man can lift. On nearly every part of this massive specimen the line where the corallites come into contact with each other is very visible, and in some places there appears to be a slight but perceptible interval between the walls. Marginal budding is frequent, and fissiparous division of the calices is observable everywhere. Some of the calices are more than an inch in length, and have a very remarkable and almost serpentine form, with four or five fossulæ, the long dividing septa being present between some of them, but not between others. At one place rejuvenescence occurs in several contiguous calices, and they appear as double, or one within the other, just as they appear in the upper part of Laube's figure of *Elysastræa*, and here and there a corallite, near the outside of the corallum, is elevated above the rest and there is a trace of an after-growth of epitheca.

HETERASTRÆA LATIMÆANDROIDEA, Dunc. sp.

Isastræa latimæandroidea, Duncan, Supp. Brit. Fos. Cor. pt. iv. p. 65, pl. xxv. figs. 18, 19.

The specimen of this species, which was obtained by Dr. Wright from the *Ammonites planorbis* bed of Street, was for some time in my hands, and a facsimile in plaster, taken by means of a wax impression, is now before me. Marginal gemmation is obviously very abundant, and the elongated calices having more than one fossula, are indicative of fissiparity. The specimen is only a fragment and its specific independence is very doubtful.

HETERASTRÆA ? SINEMURIENSIS, From. sp.

Isastræa sinemuriensis, E. de From. in Martin, Pal. Strat. de l'Infra Lias, Cote d'Or.
Isastræa sinemuriensis, Duncan, Supp. Brit. Foss. Cor. pt. iv, p. 30, pl. vii. figs. 1-9.

If the Brocastle specimens are rightly identified with this species, then it, like so many other of the so-called *Isastrææ* of the Lias, increases by marginal instead of calicinal gemmation. This is evident in my specimen, and it has also been figured by Prof. Duncan (Supp. Brit. Foss. Cor. as above) from specimens in the collection of the late Mr. Charles Moore.

Of *Isastræa gibbosa* from the same locality I can only say that in the specimens I have examined there was no evidence of any process of increase.

HETERASTRÆA EXCAVATA, Fromentel, sp.

Septastræa excavata, E. de From. in Martin, Infra Lias, Cote d'Or. 1860.

Two specimens of a Coral which I refer to this species have come into my hands, both of which were taken from the low-lying gravel at Charlton, about a mile north-west of Evesham. They resemble each other in having a regularly oval form, and are somewhat depressed, though they have an evenly convex calicular surface. A larger example than either of these would, if broken up, furnish precisely such fragments as the one figured by M. de Fromentel. In all the details of the form, size, and arrangement of the corallites and their calices, as well as the development of the septa, my

specimens are fully in accord with the fragment figured by M. de Fromentel, excepting that in addition to fissiparity there is undoubted marginal gemmation, which is, however, unfrequent, not more than three or four instances appearing on either specimen.

HETERASTRÆA ETHERIDGEI, sp. nov. Pl. VII. Figs. 1, 2.

This species, which appears to be undescribed, bears a little resemblance in the form of the corallum to *H. Haimei*, but it differs greatly in the size of the calices, which are scarcely half the size of those of the last-named species.

The corallum is tall and somewhat compressed, with a rounded top, the whole surface being closely covered with calices, which are hexagonal, shallow, and saucer-shaped. The walls are thick, but when entire come to a sharp well-defined edge, and there is a very distinct though fine line where the corallites come together, indicating imperfect union.

No cyclical numeration of the septa can be formulated. There are about twenty-four in a medium-sized and regular calice, and nearly half of them pass almost into the centre of the calice, but do not quite meet. In the elongated calices, however, the longest from the opposite sides meet in the middle line. The others are too irregular to be determined. All the septa are of medium thickness, which they maintain as they pass inwards. In an unworn calice they all have margins which are regularly tuberculated, about eight to ten prominent tubercles being observable on the longer ones.

The tallest specimen I have seen measures four inches in height, and has a diameter of about two inches. Diameter of the calices from one and a half to two lines.

Gemmation and fissiparity occur quite freely and with about equal frequency on all parts of the corallum.

I have examined several specimens from the Lower Lias of the East Cliff, Lyme Regis, and I possess one which was taken from the gravel-pit at Charlton, near Evesham.

HETERASTRÆA REGULARIS, sp. nov. Pl. VII. Fig. 7.

The corallum of all the specimens I have seen was attached by a small oblong space, from which it expanded rapidly, and was surmounted by an irregular overhanging flattened or rounded top, with some elevated lines and gibbosities. The corallites are rather small and angular, and, generally speaking, hexagonal, and their union with each other is indicated by a fine but very distinct line. The calices are deep, almost as deep as wide, and the walls are regular, thin, upright. and straight between the angles. The septa are rather regular, straight, and rather thick, and they hold their thickness quite into the centre of the calice. There are six systems, and three cycles and a rudimentary fourth. The septal edges have large rounded denticulations, which are few in number and lobular. The primary septa are six, and they unite in the centre of the calice and form a false columella, which, however, is not very apparent until the tabulæ forming the floor of the calice have been broken through.

Those of the second cycle are two-thirds the length of the first, and those of the third two-thirds the length of those of the second, while the septa of the fourth cycle are merely rudimentary.

Marginal gemmation and fissiparity both occur, but are not frequent.

This species may be readily distinguished from all the others by the small number and the regularity of the septa, the cycles of which can readily be determined in a fairly symmetrical calice. In the larger and more irregular ones, however, the septa are a little more numerous, and the cycles cannot be traced. Another distinction consists in the union of the primary septa low down below the calice, and thus forming a false columella, which becomes conspicuous when the dissepimental floor of the calice has been destroyed and the septa worn down. I have not seen this in any other species.

The most regular calices have a diameter of about two lines, but the larger and more irregular ones are nearly three lines in breadth.

Two examples have been obtained from the *Ammonites angulatus* beds in a field called "Salmon's Stile," near the village of Littleton, north-east of Evesham, and another from near the village of Cropthorne, west of Evesham.

HETERASTRÆA BINTONENSIS, sp. nov.

There is a large and nearly globular species having a very gibbous upper surface, and rather small calices with thick walls, which I have at present been unable to refer to any known species. It occurs in the *Ammonites angulatus* beds at Binton Hill, four miles west of Stratford-on-Avon, and at Down Hatherley, Gloucestershire, where my friend Mr. Brodie found a specimen, and kindly forwarded it to me for my use on the present occasion. Other specimens have been taken from the Charlton gravel-pit.

The calices are rather small, and are mostly hexagonal, but they have a rounded appearance, owing to the walls being thickened just at the angles. They are very seldom elongated. The septa are straight, thin, and in the larger calices there are from forty to forty-six. About nine or ten are longer than the others, but do not meet in the centre of the calice, there being an open fossula of nearly one-fourth of the diameter of the corallite, which is only closed by the tabular dissepiments. A corresponding number of septa are about half or two-thirds the length of the long ones, and all the others are too short and variable to be enumerated.

Gemmation occurs rather freely, but fissiparity is much less common.

The diameter of a large specimen is about six inches, of a smaller one three or four inches. The calices are from two to two and a half lines wide.

The thick walls, the more or less rounded form of the calices, and the open fossula will distinguish this species, and I may add that all the specimens I have seen have had a more or less globular form.

HETERASTRÆA sp.

I have before me several specimens of a species which is

obviously quite distinct from any of the foregoing, but which are not sufficiently well preserved to admit of description. They consist of thin plates, from half to three-fourths of an inch in thickness, which had nearly an upright position, and have calices, all of which are oblique. They were found in the neighbourhood of Evesham.

DESCRIPTION OF PLATE VII.

Fig. 1. *Heterastræa Etheridgei*, a horizontal section a little below the calice, showing the imperfect union of the corallites, fissiparity in progress in two corallites, and one corallite which has resulted from gemmation. Magnified three diameters.

„ 2. „ *Etheridgei*, a vertical section showing the dissepiments and the edges of the septa. Magnified three diameters.

„ 3. „ *Eveshami*, a portion of the type specimen showing a calice which has been developed from a bud, and still retains a more or less circular outline. Magnified two diameters.

„ 4. „ *Fromenteli*, a portion of the specimen figured by Prof. Duncan, exhibiting, in close proximity, both gemmation and fissiparity. Magnified two diameters.

„ 5 & 6. „ *Tomesi*, portions having calices resulting from both gemmation and fissiparous division. Magnified two diameters.

„ 7. „ *regularis*, some calices magnified two diameters.

„ 8. „ *Stricklandi*, some calices of a specimen from Evesham, having both gemmation and fissiparous division. Magnified two diameters.

„ 9. „ *endothecata*, a portion of the type specimen, showing fissiparous division in progress. Magnified two diameters.

III.—On Some Effects of Pressure on the Devonian Sedimentary Rocks of North Devon.[1]

By J. E. Marr, M.A., F.G.S.

During Professor Hughes' annual geological excursion, which was last Easter conducted to Ilfracombe, I was much struck with certain structures exhibited by the ordinary Devonian sediments, and some of these are, I think, worthy of a short notice. Most of them are exhibited on the beach close to Ilfracombe, at the bathing place, where there is also seen the folded grit band rendered classical through Dr. Sorby's writings.

The rocks here consist of cleaved argillaceous deposits interstratified with thin grits and limestones, and the latter have been folded amongst the former in a most remarkable manner. The changes which take place are illustrated in Fig. 1. The first stage is the production of a series of sigmoidal folds having the middle limb replaced by a thrust-plane. This is well shown in the case of two limestone bands just above a small cave on the shore, at the bathing place. A further development is shown in Fig. 1*a*, and the result of this is the formation of a series of "eyes" of limestone, which vary in length from a fraction of an inch to several feet, according to the magnitude of the folds. As the smaller folds are merely the convoluted portions of larger ones, the "eyes" get pulled out along the thrust-planes, replacing the middle limbs of the larger folds, as shown in Fig. 1*b*. In this way, the central portions of these larger folds

[1] Read at the Manchester Meeting of the British Association.

present the appearance shown in Fig. 1c, where we find a series of lengthened "eyes," forming flattened lenticular patches interbanded with the normal cleaved argillaceous material. By these simple changes we have produced a rock having all the mechanical characters of a schist, but consisting of alternating lenticular patches of limestone and clay-slate, and presenting the apparent false-bedding which is also seen in true schists. The apparent dip of the rocks is here entirely fallacious, and is due to the pulling out of the limestone "eyes," so as to have their longer axes parallel with the general strike of the cleavage planes. In many cases the cores of the larger folds have the "eyes" compressed together to form an irregular nodular mass, in which the separate "eyes" can be some-

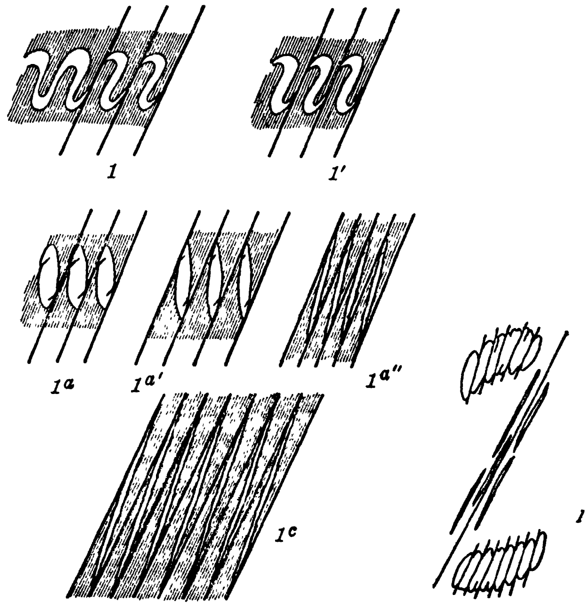


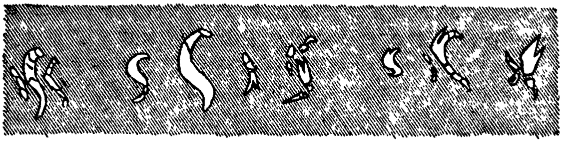
FIG. 1 1′. Transition from ordinary overfolds to the stage 1*a*.
,, 1*a*. As in text.
,, 1*a*′ 1*a*″. Transition from 1*a* to 1*c* as produced along the fault plane in 1*b*.
,, 1*b* 1*c*. As in text.

times with difficulty determined, but at other times the lines of demarcation are wholly obliterated. In these masses, the crinoid joints of which the limestones are largely composed are affected in the way described by Dr. Sorby in his Presidential Address to the Geological Society (Q.J.G.S. vol. xxxv. p. 89), and in some cases are seen converted into a number of irregular polygons. Along the planes where the limestone "eyes" have been dragged out, we find that the crinoid stems are separated in a way similar to that figured by Heim in the case of a Belemnite (Mechanismus der Gebirgsbildung, pl. xv. fig. 6), and the spaces separating the different joints are then filled with crystalline calcite.

The changes occurring in the case of the thin grit bands are generally similar to those described above; but here we find also that the particles are compressed, and there appears to have been a slight mineral rearrangement. The grits are nevertheless easily distinguishable as such even to the naked eye.

The rocks at the bathing place are furthermore traversed by quartz veins, some of which were formed before the principal folding of the rocks, and in this case, the veins are affected in the same way as the thin bands of limestone. Fig. 2 shows the foldings of such a quartz vein, as seen close to the Tunnels at the

Fig. 2.



bathing place. Here two quartz veins occur parallel with two thin bands of limestone, and are folded like the limestone, showing that the veins were formed along the bedding planes, before the latter were affected by the folding. At this spot, both limestone and folded quartz veins suddenly disappear against a large divisional plane to the right, and a few feet to the right of this plane a series of quartz veins run parallel with the cleavage planes. It is possible that the latter veins were produced by the mechanical rearrangement of the folded veins along the thrust plane of a large fold, but it is not easy to prove this, as in the case of the limestones, and the rectilinear veins may have been formed in their present condition by segregation. Upon a flat surface of rock to the south of this place, quartz veins are seen formed into "eyes," and these "eyes" in places have been almost certainly dragged out. In such cases we have the incipient formation of a schistose rock composed of alternating lenticular masses of argillaceous material, limestone and quartz. Precisely similar phenomena may be seen at Hagginton Beach and elsewhere, and indeed the whole coast offers excellent examples of the formation of these schistose structures in ordinary sediments, where all the mechanical peculiarities of a true schist are visible, without any great change in the chemical composition of the individual constituents of the rock.

At Hagginton Beach a mass of limestone occurs, which has been pulled out so as to form a series of elliptical nodules occurring in the same line. Here we find the junction of limestone "eyes" without any folding of the particular mass of limestone in which the "eyes" occur. A flattening of these "eyes" would cause the formation of lenticular masses of limestone of a similar character to those described as occurring at the bathing place; nevertheless the mode of formation of the "eyes" is quite different in the two cases.

Some of the smaller "eyes" seen in a cliff just north of Hagginton Beach are composed of masses of coral. The elliptical shape of the

"eyes" does not appear to be due to the original growth of the coral, for the sides of the nodules are seen to consist of sections of the coral. This may be owing to chemical solution of some parts of the limestone, but appeared to me to be caused by the actual shearing off of a portion of the coral. This supposition requires confirmation, and it is probable that a fuller examination of the district will yield the requisite evidence.

The structures seen in these North Devon rocks remind one of those described by Dr. Bonney as occurring at Tor Cross in S. Devon (Q.J.G.S. vol. xl. p. 1). He brings forward proof to show that in that region "there is no valid evidence of a passage from schist to slate." The occurrence of rocks in North Devon having all the mechanical structures of true schists, without possessing their peculiar chemical composition, bears out this conclusion. In connection with this, it is of interest to notice that whereas in South Devon, where phyllites are found associated with normal schists, the sedimentary rocks are largely penetrated by igneous intrusions, this is not the case in North Devon, where such intrusions are very rare. One mass of quartz felsite, which has been described by Dr. Bonney (Geol. Mag. 1878, p. 207), does occur at Bittadon, and he states that it is "affected slightly by cleavage." It was therefore intruded prior to the last earth-movements of this area. In some parts of the rock there is a parallelism of the alteration products which have been developed along the line of cleavage, but unfortunately the portion of the rock which has undergone the greatest amount of cleavage is so decomposed that no specimen could be obtained sufficiently firm for slicing. The apparent absence of schistosity in this rock can be however accounted for on the supposition that at the place where it is exposed, the mass forms an "eye" which has not undergone any great change. It would be of interest to know if this rock is exposed elsewhere, and if so, under what conditions it is there found.

I am indebted to Mr. E. J. Garwood, B.A., F.G.S., for the use of photographs displaying many of the structures which I have described above.

IV.—Notes on the Geology of Mynydd Mawr and the Nantlle Valley.

By Alfred Harker, M.A., F.G.S.,
Fellow of St. John's College, Cambridge.

MYNYDD MAWR, about three miles west of Snowdon, is an abrupt rounded hill, 2300 feet high, separating the valleys of Nantlle and Cwellyn. A reference to the maps of the Geological Survey (75 N.E. and N.W.) shows it to be due to an isolated boss of "intrusive hornblende-porphyry" in the form of a rounded parallelogram, a mile and a half in its longest diagonal. Dr. Hicks[1] has mapped this patch as Pre-Cambrian, and included it in his Arvonian system; but apart from its position, breaking

[1] Q.J.G.S. vol. xxxv. p. 297, 1879.

through a regular succession of Cambrian (or Ordovician) rocks, an examination of the junction affords convincing proof of its intrusive character. On the northern flanks of the hill the relations are well exhibited, and the induration and extensive mineralogical alteration of the slate in the vicinity of the boss are very marked. It is indeed by no means easy to determine on the ground the precise point where the hardened, semicrystalline slate gives place to the porphyry.

The question may, however, be approached on a different line, which indicates a higher, as well as a lower, limit to the age of the intrusion. A series of observations with compass and clinometer may, I believe, be made to yield interesting results in many districts of cleaved rocks, and so no apology seems needed for introducing in this connection a few remarks on the arrangement of the cleavage-planes in the slaty rocks of the Vale of Nantlle.

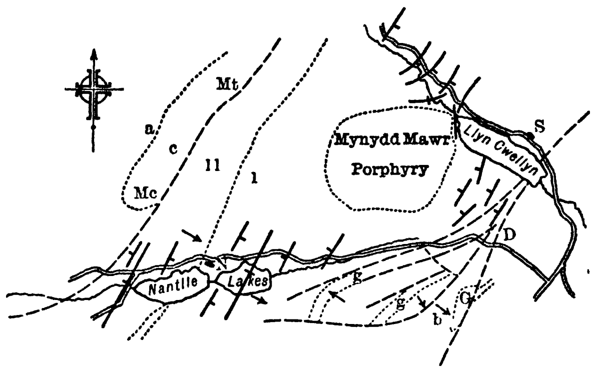
All the peculiarities of slaty cleavage may be studied to advantage in the slate-quarries of the lower part of the valley, which are worked in Lower Cambrian rocks resembling those of Llanberis. Here, as usual, a great perfection of the cleavage-structure is found associated with high angles of cleavage-dip. The cleavage-strike seldom deviates more than a few degrees from N. 36° E.—S. 36° W., which is also about the *normal* strike of the strata, in accordance with the law developed by Sedgwick, Darwin, Jukes, and others. It also agrees nearly with the trend of the great Archæan ridge, which extends from Llanllyfni to beyond Llanberis. The quartz-porphyry composing this ridge has itself been structurally affected by the same stress which originated the cleavage of the neighbouring slates. The platy structure of the mass, well seen at Cilgwyn, Pen-y-groes, etc., has the same strike; it is not mere jointing, but is often seen to be in direct relation with a certain schistosity of the quartz-porphyry.

The variations of cleavage-dip in the Nantlle slates agree well with the rules laid down by Sharpe forty years ago. A little west of the lower lake runs a line of vertical cleavage, nearly coinciding with the bye-road from Tal-y-sarn to Llanllyfni. On each side of this line of strike the cleavage-planes dip away from it at high angles, so that the cleavage-dip in the Pen-y-bryn and other quarries near Nantlle itself (Nant-y-llef on the maps) is south-easterly. Another line of vertical cleavage passes through the middle of the upper lake, and in the slates on each side of this the cleavage-planes dip in towards this line. The north-westerly cleavage-dips hold up the valley with a gradually decreasing angle, to 56° at Drws-y-coed Pass. The strike of the cleavage remains very constant in these higher beds, although the strata themselves in the neighbourhood of the Tal-y-mignedd copper-lodes change their bearing considerably, curving round towards the east. This is an example of the law that the cleavage of a district, while following the trend of the main axes of disturbance, is independent of minor variations in the strike of the strata. Occasionally local irregularities occur, which are clearly traceable to subsequent faulting. It is noticeable that, with

decreasing angles of cleavage-dip, the cleavage-structure becomes less perfect, and the rocks cease to be worth working for slates.

A similar regularity may be traced in the cleavage of the rocks in the Cwellyn Valley on the north side of Mynydd Mawr, the average strike being towards N. 30° E., with small deviations, and the dip of the planes varying gradually as before. In the neighbourhood of the hill itself, however, the case is different. Considerable deviations present themselves, and these are found to follow a definite law: in brief, the cleavage-strike becomes more and more changed

Sketch-Map of Mynydd Mawr District.



Scale: One inch to two miles.

S, 'Snowdon Ranger;' D, Drws-y-coed; G, Y Garn; N, Nantlle; Mc, Mynydd Cilgwyn; Mt, Moel-y-Tryfaen: *a*, Archæan ridge; *c*, Cambrian basement conglomerate; *ll*, Slates of Nantlle quarries = Llanberis series; *l*, Higher slates = Lingula flags and newer beds; *g*, Grits of Tal-y-mignedd (? Arenig age); *b*, Slates of Bala stage.

— — — Faults; ↘ Dip of strata; —┬— Strike and dip of cleavage; —┼— Vertical cleavage.

as we approach the porphyry, *tending always towards parallelism with the boundary of the intrusive mass.* For instance, on the north side the cleavage-strike becomes deviated so as to bear always more easterly, as far as N. 70° E. and even N. 85° E., with increasingly high dips towards the south-east and south. This variation cannot be traced so far as the actual junction, for the rock there is so indurated that it has been able to resist the mechanical stress. On the east side of the hill, on the other hand, the cleavage-strike is deviated towards the north, and in the narrow strip of slates where the lake approaches most closely to the porphyry, the cleavage bears due N.—S., with a dip of 83° to the west. Doubtless, if we could lay bare the whole tract, the cleavage-strike would be seen curving round the mass of porphyry, just as the lines of flow in a rhyolite curve round a porphyritic crystal, or as the fibres of wood are deflected by a knot.

The only explanation of the peculiarities just described is that, when the whole district was operated upon by the powerful lateral pressure which produced the cleavage-structure, the unyielding mass

of porphyry interposed a hard obstacle; in its neighbourhood, therefore, the resultant compression tended to be perpendicular to the boundary of this obstacle, and so the cleavage-surfaces produced tended to be parallel to the boundary. A little consideration will show that such great deviations could not be brought about by disturbance due to the intrusion of the porphyry *after* the impression of the cleavage-structure. Moreover, in such a case, the cleavage-planes, owing to their very high angles of dip, would have been less affected as regards strike than the strata. The bedding is in fact disturbed near the junction, but no great changes in its direction of strike are to be noticed. Again, we have seen that the cleavage-planes on the north side of the hill dip towards it, and the angle of dip increases on approaching the porphyry, until vertical. If the intrusion had disturbed the rocks after they had become cleaved, the reverse should be the case.

It appears certain then that the porphyry of Mynydd Mawr is truly intrusive; that it is newer than the surrounding rocks, but older than their cleavage. The rocks in question are probably Arenig, though possibly older, their age, in the absence of fossils, being necessarily in doubt (Ramsay, Geol. N. Wales, 2nd ed. p. 168). The era of the cleavage is, according to all the evidence obtainable, the close of the Cambrian period of Sedgwick, or at least, as Sir A. Ramsay puts it, "before the commencement of the deposition of the Upper Llandovery strata" (*ibid.* p. 326). The intrusion of Mynydd Mawr, then, may well be of Bala age. Ramsay remarks that the summit of Y Garn, about two miles south of Llyn Cwellyn, which is mapped as "greenstone," consists of an igneous rock similar to that of Mynydd Mawr, and the slates on its western side, which form part of the Bala stage, are seen to dip under the rock in question. The vertical cleavage of the slates near the junction of the Mynydd Mawr mass indicates that the boundary of the latter is nearly perpendicular. It seems very probable then that this great boss of porphyry is the plug of a volcanic vent of Bala age, and may mark the source of some of the lavas of Snowdon, Moel Hebog, and Llwyd Mawr.

If this be so, a petrological examination of the Mynydd Mawr rock will have a special interest. Without attempting a complete description of it, its chief characters may be briefly noted. The rock is unique in appearance and easily recognized when met with in the drift of Moel Tryfaen and Nantlle. To the eye it appears as a bluish-grey compact mass, pinkish or cream-coloured when weathered, in which are imbedded imperfect linear crystals of a lustrous black, arranged in parallel streams. The general characters are very constant throughout the whole extent of the hill: the black crystals, however, usually about a quarter of an inch in length, sometimes attain a larger size; felspar crystals are often visible, and scattered grains of quartz. The mass exhibits a platy jointing, sometimes in two intersecting directions, and about Craig-cwm-bychan the columnar structure is often very marked.

Sir A. Ramsay (*op. cit.* p. 171) refers to the black crystals as

hornblende, but in the late Mr. E. B. Tawney's copy of the memoir this is altered in the margin to "tourmaline." An examination of several thin sections of the rock reveals always both minerals in close association and in about equal quantities.

The microscope shows a fine-grained ground-mass, enclosing, besides the hornblende and tourmaline, porphyritic felspars and sometimes crystalline grains of quartz. Some of the black crystals of the hand-specimens are seen to be hornblende, some tourmaline, while others consist of both minerals closely associated, with a very irregular or ragged line of junction. The boundaries of the crystals show no idiomorphic outline, but an extremely ragged edge, owing to their including granules of quartz and felspar similar to those of the ground-mass. Most of the crystals, too, both hornblende and tourmaline, contain these granules throughout their interior, so that the sections, instead of being solid, have a porous or spongy appearance.

The tourmaline is of the blue variety of that mineral, and the absorption, for both ordinary and extraordinary rays, is so complete that slices of the usual thickness are almost opaque, giving in their thinnest portions a deep indigo-blue tint. No traces of cleavage are apparent.

The hornblende has the usual prismatic cleavage well marked. It is remarkable chiefly for its abnormal colours and intense dichroism. Vibrations parallel to the a-axis of elasticity give a rather light brown colour, those parallel to β and γ a very deep blue, having perhaps a greenish tinge in the former case and indigo in the latter, but the absorption is so strong that the crystals appear almost opaque when the a-axis is approximately perpendicular to the shorter diagonal of the Nicols prism. This deep tint is indistinguishable from that of the tourmaline in the same slides.

The porphyritic felspars present square sections, twinned apparently on the Carlsbad model. They may be orthoclase, but are too much destroyed to allow of identification. These crystals are of earlier consolidation than the hornblende and tourmaline.

The ground-mass is a finely granular admixture of quartz and orthoclase, as in an ordinary "micro-granite," but containing in addition another mineral which is often plentiful. It occurs in minute crystals, of acicular or rectangular form, scattered through the ground-mass or included by the other constituents, and having usually a fluxional arrangement agreeing with that of the parallel hornblende and tourmaline streams. The mineral is colourless, or in the larger crystals gives for vibrations parallel to the long axis a faint tint of indigo-blue. The crystals give high polarisation colours and straight, or nearly straight, extinction. They have a high refractive index, which causes them to stand out in relief when viewed by ordinary transmitted light. They may perhaps be another generation of tourmaline.

These acicular crystals evidently belong to an early stage of the solidification of the magma, and it is important to notice that their disposition agrees with the fluxional arrangement of the visible

black crystals, which must have consolidated almost at the same time as the granular ground-mass. The structure of the rock seems not incompatible with the idea that it was formed in the pipe of a dying volcano, when the upward flow became gradually arrested and the remaining magma slowly solidified into a plug under the pressure of the superincumbent column. Tourmaline, though not a constituent of true lavas, is by no means unknown in the quartz-porphyries of some other districts: the blue variety occurs, for instance, in the Harz Mountains.

P.S.—With reference to the discovery of glaucophane in Anglesey, announced by Prof. Blake in the March Number of this MAGAZINE, it may be noted that the blue amphibole of the Mynydd Mawr rock differs from that mineral in the character of its absorption and pleochroism, as well as in the absence of crystal form and of the peculiar "cross-jointing." Glaucophane has not, I believe, been recorded from non-metamorphic igneous rocks. A good *résumé* of the literature relating to this mineral has recently been given by Oebbeke.[1]

V.—NOTE ON THE SPICULES DESCRIBED BY BILLINGS IN CONNECTION WITH THE STRUCTURE OF *ARCHÆOCYATHUS MINGANENSIS.*

By GEORGE JENNINGS HINDE, Ph.D., F.G.S.

IN "The Palæozoic Fossils of Canada," vol. i. p. 3, the late Mr. Billings stated that by treating a silicified specimen of *Archæocyathus Minganensis* with acid, he ascertained that it contained numerous siliceous spicula—slender, fusiform, slightly curved, acute at both extremities—and that these fossils must therefore be classified among the extinct tribes of sponges. Referring again to this species in the latter part of the same volume (pp. 354-357), this author states that he had found the same spicula present in great numbers in another large species, *Trichospongia sericea*, and that it therefore remained an open question whether they actually form part of the structure of *Archæocyathus*, or belonged to *Trichospongia*. In addition, however, to these simple detached spicules, Mr. Billings describes and figures (*loc. cit.* p. 355, fig. 344) "branching spicula," which "are seen imbedded in, and forming a part of, the substance of the outer wall of *A. Minganensis*." No doubt could be entertained that these so-termed branching spicula really belonged to the fossil, since they could "be seen, not only projecting from the surface of the silicified specimens, but also in the thin slices prepared for the microscope."

Since the description of *Archæocyathus* by Mr. Billings appeared, the nature of this fossil has been investigated and referred to by several eminent palæontologists, amongst whom may be mentioned,

[1] See Ueber den Glaukophan und seine Verbreitung in Gesteinen, von Herrn K. Oebbeke, Zeitsch. der deutschen Geologischen Gesellschaft, 1886, vol. 38, p. 634.

Meek,[1] Dawson,[2] Ferd. Rœmer,[3] Börnemann,[4] Walcott,[5] and Schlüter,[6] but it cannot as yet be said that any satisfactory or decisive conclusion as to its character and affinities has been arrived at. Mr. Billings's statement as to its spicular structure has considerably increased the perplexity of the subject and influenced opinion in favour of its alliance[7] to sponges; any fresh information therefore respecting the nature of these spicules and their relation to the fossil *Archæocyathus*, may help to remove an element of uncertainty in the consideration of the question as to its true nature.

Fig. 1.

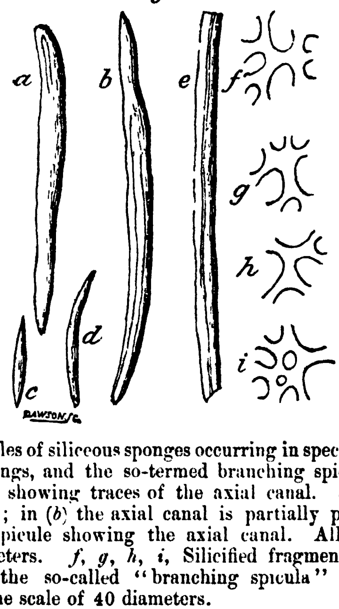


Fig. 1. Detached spicules of siliceous sponges occurring in specimens of *Archæocyathus Minganensis*, Billings, and the so-termed branching spicula of the same fossil. *a*, Acuate spicule, showing traces of the axial canal. *b*, *c*, *d*, Different forms of acerate spicules; in (*b*) the axial canal is partially preserved. *e*, Fragment of a cylindrical spicule showing the axial canal. All enlarged to the same scale of 40 diameters. *f*, *g*, *h*, *i*, Silicified fragments of the outer wall of *A. Minganensis*, the so-called "branching spicula" of Billings. Reduced from Billings to the scale of 40 diameters.

Through the kindness of Sir J. W. Dawson, F.R.S., I have been supplied with a small quantity of the original material obtained by Mr. Billings through treating fragments of rock containing *Archæocyathus* with acid, and from which the spicules were procured, which, as already mentioned, have been described and figured as probably belonging to this fossil. The coarser portions of this residual débris are irregular-shaped siliceous fragments, of a grey tint, showing in

[1] American Journ. of Science, n.s. vol. 45 (1868), p. 62; vol. 46, p. 144.
[2] Life's Dawn on Earth, p. 154.
[3] Lethæa Palæozoica, p. 301.
[4] Versteinerungen der Insel Sardinien (1886), p. 28.
[5] Cambrian Faunas of North America, Bull. No. 30, U.S. Geol. Surv. (1886), p. 72.
[6] Zeitsch. d. deutsch. Geol. Gesellsch. 1886, p. 899.
[7] Thus we find one of the latest writers on it, Mr. C. D. Walcott, stating that the presence of spiculæ in this species associates it with the Spongiæ, close to the family Euretidæ of Zittel, and he considers that the spiculæ "in several of the species have been lost in the crystallization of the calcite now forming the skeleton," *l.c.* p. 80.

places on their outer surfaces small rounded granules like those of Beekite. The fragments are in part porous, and several of them are filled with fragmentary spicules dispersed irregularly in the rock, and apparently in various stages of dissolution. In the finer débris are smaller particles of silica and detached entire and broken spicules. From these I have picked out fairly complete fusiform acerate spicules (Fig. 1, *b*, *c*, *d*), acuate or pin-shaped spicules (*a*), and portions of nearly cylindrical forms (*e*). The spicules are of chalcedonic silica, and their axial canals are preserved in many instances. They are common types of siliceous monactinellid spicules, and belong to at least four species of sponges. Forms of a similar character, and similarly detached, are very abundant in the cherty beds of the Yoredale rocks of Yorkshire. I have but little doubt that these siliceous fragments from the Mingan strata, in which *Archæocyathus* occurs, have been produced by the dissolution of the spicules of disintegrated monactinellid sponges, and the redeposition of the silica as Beekite.

I have not, however, detected in the débris examined a single fragment of the so-termed 'branching spicula' (Fig. 1, *f*—*i*), described and figured by Billings as forming part of the substance of the outer wall of *A. Minganensis*. Judging from the figures given of them, I do not think they can be regarded as spicules; they are merely abruptly broken fragments of what appears to have been a delicate continuous porous membrane; no two of them are similar, and they do not bear any definite resemblance to any sponge spicules with which I am acquainted. I have no doubt that—as stated—they form part of the outer wall of *Archæocyathus Minganensis*, but instead of being 'branching spicula,' they are merely broken portions of the calcareous tissue of the outer wall, replaced by silica. The structure of the outer wall in the allied species *A. Whitneyi*, Meek, is described[1] as consisting of minute punctures so closely crowded that the little divisions between them are scarcely equal in breadth to the punctures themselves, and form, as it were, an extremely delicate kind of network, and the so-termed 'branching spicula' in *A. Minganensis* might well be broken-up portions of a network of this character.

Therefore as regards the true sponge-spicules associated with *A. Minganensis*, it is evident there is no other connection between them and this species than the accident of position, and the so-termed branching spicula, which really belong to this fossil, are in all probability mere siliceous replacements of the tissue of its outer wall. Thus in neither case is there any evidence in support of the view that *Archæocyathus* is allied to *siliceous* sponges. My knowledge of this puzzling fossil is insufficient for me to give a competent opinion as to its real nature; it is fairly certain, however, that its skeleton was originally calcareous, and it is just possible that careful microscopical examination might give a clue to its relations.

[1] American Journ. Sci. vol. xlv. p. 62.

I.—On Two New Forms of Polyodont and Gonorhynchid Fishes from the Eocene of the Rocky Mountains. By Prof. E. D. Cope. Mem. Nat. Acad. Sci., vol. iii. pp. 161–165, with double plate.

IN 1883 (Amer. Nat. p. 1152) and again in 1885 (*ibid.* p. 1090), Prof. Cope briefly noticed a portion of the trunk of a fish from the Eocene of Wyoming, displaying many points of resemblance to the living Acipenseroid *Polyodon*, but remarkable on account of its possession of distinct scales, not confined to the upper lobe of the tail. The genus and species received the name of *Crossopholis magnicaudatus*, and in the present memoir Prof. Cope adds a detailed description, with figures, making known also a considerable portion of the skull of the fish. In many respects, the cranial bones are very similar to those of *Polyodon*, but the snout is relatively shorter, and more closely corresponds in form to that of *Psephurus*. The body is long and slender, with short dorsal and anal fins, remotely situated. and the former commencing slightly in advance of the latter. The scales are numerous, in oblique series, not quite in contact; and each consists of a small subquadrate disk, with a row of long, sharp, backwardly-directed spines arranged upon the posterior margin. In an individual measuring 0·170 m. from the anterior extremity of the dorsal fin to the notch of the caudal, the scales only measure about one millimetre each way: the caudal fulcra are large and strong. Another novelty from the Wyoming shales first noticed by Prof. Cope in 1885 (Amer. Nat. p. 1091) is also figured and described in detail, namely, the *Notogoneus osculus*. This is of great interest as being scarcely distinguishable from the living *Gonorhynchus*, except in the dentition; for the latter genus—the only representative of its family previously known—is solely confined to the seas of South Africa, South and Western Australia, and Japan. As well remarked, "The discovery of this type in the Eocene beds of North America is a notable addition to ichthyological science. It is parallel with the occurrence of the family of the Osteoglossidæ in the same formation, a family also now confined to the Southern Hemisphere." The memoir concludes with a figure and description of a small *Priscacara*, supposed to be adult and referable to a new species, *P. hypsacanthus*; and it is also added that a newly acquired specimen of *P. serrata* displays massive superior and inferior pharyngeal bones, covered with obtuse grinding teeth. A. S. W.

II.—Eocene Chelonia from the Salt Range. By R. Lydekker, B.A., F.G.S. Palæont. Indica, ser. 10, vol. iv. pp. 59—65, plates xii. and xiii. 1887.

TWO interesting Chelonian fossils were obtained from the Lower Eocene of Nila, in the Punjab Salt-Range, by Dr. H. Warth, in 1886, and presented by him to the Indian Museum, Calcutta. These form the subject of the present memoir, and are interesting as being the only known Indian Chelonia of earlier date than those

of the Siwalik period, with the exception of the small *Platemys Leithi* from the inter-trappean beds of Bombay. The first specimen described comprises the greater portion of the carapace and plastron of a Pleurodiran Chelonian, characterized by the absence of epidermal shields. In the latter feature it agrees precisely with the genus *Carettochelys*, recently discovered by Dr. E. P. Ramsay in the Fly River, New Guinea, and may therefore be placed in the family of *Carettochelyidæ*, as defined by Boulenger; its generic distinctness, however, is indicated by the neural plates being in contact, not separated by the costals, and also perhaps by the presence of a mesoplastron. The plastron is marked by a pitted sculpture, and the genus and species receives the name of *Hemichelys Warthi.* The second fossil is much less complete than the first, and is provisionally referred to a new species of *Podocnemis*, under the name of *P. indica.* The greater portion of the carapace is preserved, and its total length would probably be about 35 inches; it is oval, tectiform, not keeled, and narrowed posteriorly. Though now confined to South America, the occurrence of *Podocnemis* and *Platemys*, in the Indian Tertiaries, is not an altogether unexpected fact, the former, at least, also being met with in the Lower Eocene of England; and, as Mr. Lydekker remarks, the available evidence now seems to point to the conclusion, that the original habitat of this group of fresh-water Chelonia was in the northern portion of the Old World, whence they have been driven perhaps by the competition of the Emydians.

A. S. W.

III.—Om Postglaciala aflagringar med *Ancylus fluviatilis* på Gotland. Af Henr. Munthe. Öfversight af Kongl. Vetensk.-Akad. Förhandlingar, 1887, No. 10, pp. 719–732.

On Post-Glacial Deposits with *Ancylus fluviatilis* on the Isle of Gotland. By Henry Munthe.

DURING the last three summers the author of this paper has been investigating the Quaternary deposits of the Isle of Gotland, and he has discovered in various localities shore-deposits or raised beaches (Strandvallar) at different elevations up to 150 feet above the present sea-level, which contain the shells of freshwater mollusca exclusively, more particularly of *Ancylus fluviatilis* and *Limnæa ovata.* These deposits consist of rounded stones, coarse and fine gravels, and intercalated beds of fine sand, they are chiefly re-arranged glacial deposits formed from the limestone of the district. The shells usually occur in the layers of sand. In 24 localities examined, the *L. ovata* is found in all save one, and the *Ancylus* in 19, whilst species of *Pisidium* are present in 10. Other species of less frequent occurrence are *Limnæa palustris, Planorbis contortus* and *marginatus, Valvata cristata* and *Bythinia tentaculata,* with some Ostracoda. The shells are usually well preserved.

Some of these raised shelly beaches are situated on the summits of partially or entirely isolated limestone plateaux, where there is not the least ground for supposing the former existence of small

freshwater lakes, nor is there any possibility that the shells can have been washed into the sea by rivers and then re-deposited in the beaches. The author believes that these beaches were formed at a time when the Baltic was a freshwater sea containing a molluscan fauna whose principal representatives are the above-named species of *Ancylus* and *Limnæa.*

There are also on the Isle of Gotland raised beaches of marine origin containing *Litorina*, etc., which are seldom at a higher level than 50 feet, though one has been described by Lindström near Wisby, which is 80 feet above the sea-level. The marine raised beaches are, however, at a distinctly lower level than those with freshwater shells, and must have belonged to a later period, when the freshwater fauna had been supplanted by marine forms.

Shell-beaches of a similar character and relative position, and containing the same freshwater mollusca, have been described by Friedr. Schmidt in Esthonia and on the islands of Ösel and Mohn, but this author regards them, in part at least, as river-deposits, although there are no distinct traces of old river-beds in the localities where they occur.[1] Prof. James Geikie has also referred to these Russian deposits as indicating that the Gulfs of Finland and Bothnia were freshwater seas at the close of the Glacial period.

Further discoveries are requisite before it is possible to lay down approximately the limits of the Baltic at the time when these Gotland freshwater beaches were formed, or to ascertain the nature and position of the barrier which dammed its waters 150 feet above their present level; but the author concludes that its northern half at least, together with the Gulfs of Finland and Riga, formed at the time a single freshwater basin. G. J. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—March 28, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On some Eroded Agate Pebbles from the Soudan." By Prof. V. Ball, M.A., F.R.S., F.G.S.

The majority of the pebbles in a collection made by Surgeon-Major Greene in the Soudan, and presented by him to the Science and Art Museum in Dublin, are of very similar character to the agate and jasper pebbles derived from the basalts of India. It may be concluded inferentially that they came originally from a region in which basaltic rocks occur to a considerable extent. A certain number of them are eroded in a manner unlike anything noticed in India, though it is probable that similar eroded pebbles will eventually be found there.

Throughout India, wherever there is deficient subsoil-drainage or excessive evaporation and limited rainfall, salts are apparent either in supersaturated subsoil-solutions or as crystallizations in

[1] Prehistoric Europe, p. 470.

the soil. They are most abundant in basaltic regions, and in a lake occupying a hollow in the basalt in Berar carbonate of soda is deposited in abundance from the water, which becomes supersaturated during the summer.

The author commented on the efficacy of such a liquid as a solvent of silica, and noticed the selective action of the agent which had affected the Soudan pebbles and had corroded some layers more than others; he suggested that while this might be to some extent due to differences in composition, it was more probably owing to differences of nodular constitution. He considered it unnecessary to refer to the action of humic acid, because while the salt to which the solvent action is attributed would be capable of doing such work, and would be probably abundant in the region referred to, we could not expect any great amount of humic acid in the same area.

2. "On the Probable Mode of Transport of the Fragments of Granite and other Rocks which are found imbedded in the Carboniferous Limestone of the Neighbourhood of Dublin." By Prof. V. Ball, M.A., F.R.S., F.G.S.

Angular fragments of granite and of schist, quartzite, and vein-quartz, such as might have been derived from the metamorphosed rocks which rest on the granite near Dublin, have been discovered in beds of Carboniferous Limestone, which often contain fragments of fossils, especially Encrinites. They have been previously noticed by Professor Haughton, Mr. H. B. S. Montgomery, Prof. Jukes, and Mr. Croll. While Prof. Jukes refers their transportation to the agency of land-plants, Mr. Croll quotes their occurrence in support of his argument as to the existence of glacial conditions during the Carboniferous period.

The author observed that the specimens exhibited none of the indications of the existence of glacial conditions, whether we regard the characters of the boulders or the nature of the rock in which they are imbedded, which contains no such silt as that occurring in the boulder-bed of the Talchir formation. Whilst rejecting the view that they were transported by ice, he pointed out that they need not necessarily have been carried by land-plants, but that they might have been torn from the sea-floor by marine algæ, some of which may have had a more buoyant character than those of modern seas. He cited the case of a sandy beach in the neighbourhood of Youghal, which is strewn with limestone fragments, which had been conveyed by seaweeds thrown up after storms from submarine banks.

It was suggested that the occurrence of natural fissures in the rocks and cracks produced by concussions from large masses hurled about by the waves might sufficiently explain how the fragments could be freed from the main mass of the reefs under the stress of the waves.

3. "The Upper Eocene, comprising the Barton and Upper Bagshot Formations." By J. Starkie Gardner, Esq., F.G.S., and Henry Keeping, Esq., with an Appendix by H. W. Monckton, Esq., F.G.S.

The familiar Upper Eocene having been transferred to the Oligocene, the remaining uppermost division of the Eocene bears the title Middle. Unless the considerable literature relating to the Brackle-

sham, the Calcaire Grossier, and the Nummulitic, is to be rendered obsolete, their classification as Middle Eocene must be preserved, and a modified Upper Eocene constructed out of the Barton series. The authors' proposal is that the following should be adopted :—

	London Area	Hampshire Area.
Upper Eocene	———	Upper Barton.
	———	Middle „
	Upper Bagshot Sands.	Lower „

The base of the formation is not sharply defined, but it coincides with the final disappearance of several subtropical Mollusca, and almost with the extinction of Nummulites in our area. The upper limit is drawn at the base of the Lower Headon, where the brackish fauna gives place to one of fresh water.

The conditions of deposition were examined at some length, and evidence in support of the estuarine origin of the formation was adduced. The section in Christchurch Bay was described first, and the thickness and characteristics of each subdivision given, the total reaching 170 to 180 feet. It commences with 45 feet of whitish sand, and, in ascending order, a pebble-bed, 11 feet of greenish clay, and a band of imperfect ironstone underlying the zone of *Nummulites elegans*. Then 20 feet of stiff drab clay, 13 feet of drab clay with sand-drifts, and 12 feet of the same, known as the Highcliff Sands. The Lower Barton terminates with the *Pholadomya*-bed. The fauna of this division comprises many Bracklesham species, which range no farther up, and a large number of peculiar species. The most convenient base-line for the Middle Barton is the lowest of several bands of Septaria, which distinguish the 50 feet of drab clays which are comprised in it, and it terminates in a very remarkable formation known as the shell-bed, which, though only a foot or two thick at Highcliff, thickens to about 15 feet to the east, and to 22 feet in the new Christchurch cutting. The finest Barton fossils are obtained from the Middle division; but though so many splendid species characterize it, few are absolutely confined to it. The upward range of a further number of Bracklesham species ceases at the shell-bed. The Upper Barton includes the *Chama*-bed, the Becton Bunny and the Long-Mead-End beds.

The Becton Bunny beds, 52 feet thick, are sand in the lower half and sandy clay above—*Oliva Branderi* is the characteristic fossil, and a large number of bivalves and brackish Headon Gasteropods come in. Opinions have differed considerably as to whether these beds should be included in the Bartons. The series closes with the Long-Mead-End Sands, 20 feet thick, with similar fossils, and formerly known as the Upper Bagshot Sands of the Hampshire basin. The section is continued without any break into the Lower Headon.

The next section described was that exposed in the cuttings for the new line from Brockenhurst to Christchurch, and here great changes in the relative thicknesses are seen, confirming the view that the Barton formation is the local deposit of a limited estuary. The *Chama*-bed remains 18 feet thick, but the shell-bed thickens to 22 feet, and the drab clay with Septaria is only 10 feet. The under-

lying greenish compact clay looks like Lower Barton, but may belong to the Middle. The Upper Bartons are much weathered and unfossiliferous, but the *Paludina*-beds of the Lower Headon do not appear for 3900 yards east. Some of these, 2330 yards west of the Brockenhurst road, are violently contorted.

The Alum-Bay section was then compared with those previously given, and the authors also noticed the Bracklesham, Stubbington, and Hunting-Bridge sections to show the transitional character of the highest of the Bracklesham beds. The paper concluded with an analysis of the fauna, and carefully revised and tabulated lists.

Mr. Monckton, in his Appendix, stated that in the London basin the Barton beds are represented by the Upper Bagshot Sand, a mass of yellow or nearly white sand without clay-beds, though often loamy. Its greatest proved thickness is 228½ feet, and the base is marked by a very persistent bed of pebbles.

Its extent is considerably greater than is shown on the Geological Survey map.

Casts and impressions of shells are abundant in some places, but recognizable species have only been found at Tunnel Hill near North Camp Station, Aldershot. A large collection from this place has been made by Mr. Herries and by the author.

II.—April 11, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read :—

1. "On the Lower Beds of the Upper Cretaceous Series in Lincolnshire and Yorkshire." By W. Hill, Esq., F.G.S.

The Red Chalk which forms the basement-bed of the Upper Cretaceous in Lincolnshire and Yorkshire is a continuation of the Hunstanton Limestone. Its thickness increases in South Lincolnshire to thin away again in the north of that county; but it again increases north of the Humber for a while. Near its most north-westerly exposure on the Yorkshire Wolds the red colour is lost; but *Inoceramus sulcatus* and *Belemnites minimus* are found in a dirty yellow-coloured material of trifling thickness. Eastwards it regains its red colour and thickness, so as to be upwards of 30 feet at Speeton, where also it is less calcareous. This section was described in detail, and the results compared with those of other writers. The author speculated upon the probable limits of the Upper Cretaceous sea at this period on evidence mainly based upon the amount of matter of inorganic origin. He noted that *Am. interruptus* has been found at Withcall, *Am. rostratus* at South Cave, and *Am.* ? *auritus* at Wharram Grange.

The base of the Chalk Marl through Lincolnshire continues to be marked by a bed of compact limestone, which is the representative of the "sponge-bed" of Hunstanton. This can also be traced in Yorkshire as far as the north-western extremity of the Wolds. Above this a few feet of grey gritty chalk retain the character of the "*Inoceramus*-bed" throughout the area above mentioned. At the north-western extremity of the Wolds the main mass of the Chalk Marl has diminished in thickness, but more than recovers

this at Speeton, where, according to the chemical and microscopical evidence, there is a complete passage from the "Gault" to the "Chalk Marl." The peculiar development of the latter at Speeton was very fully described. No bed such as the Cambridge Greensand or the Chloritic Marl can be taken as a line of separation.

Throughout Lincolnshire and Yorkshire certain courses of grey-coloured chalk are recognizable on the horizon of the Totternhoe Stone: these are known collectively as the "Grey bed." Much comminuted shell and numerous Pectens characterize this bed, which is faintly recognizable even at Speeton. The "Grey bed" determines the upper limit of the Chalk Marl. The equivalents of the Grey Chalk vary less in thickness throughout the area than those already described. Certain lithological characters, which first begin to manifest themselves in the marly beds just above the Totternhoe Stone in Norfolk, become greatly developed in South Lincolnshire, and throughout that county, as in Norfolk, the Grey Chalk is usually of a marly nature. In Lincolnshire there is much red colouration on this horizon. The occurrence of *Belemnitella plena* in Lincolnshire has been recognized. The band of bluish black clayey material in which it occurs at Barton continues throughout Yorkshire, but no Belemnite has yet been found. Allusion was made to the characteristic features towards the base of the Middle Chalk. Lists of fossils were given, and a new species of *Holaster* (*H. rotundus*) was described. Numerous chemical analyses and microscopic details of structure were also given.

2. "On the Cae-Gwyn Cave, North Wales." By Henry Hicks, M.D., F.R.S., F.G.S., with an Appendix by C. E. De Rance, Esq., F.G.S.

The author gave an account of the exploration of the cavern during the latter part of 1885, and during 1886–7. He considered that the results obtained during that time proved conclusively that there was no foundation for the views of those who contended that the drift which covered over the entrance and extended into the cavern was *remanié*, but they proved that the deposits which lay over the bone-earth were *in situ*, and were identical with the normal glacial deposits of the area. These deposits had once extended continuously across the valley, and the cavern (400 feet above Ordnance Datum) had consequently been completely buried beneath them.

The cave must have been occupied by animals during the formation of the bone-earth, before any of the glacial deposits now found there had accumulated, and a thick floor of stalagmite had covered this "earth" before the cavern had been subjected to water-action. This action had broken up the floor, and completely re-sorted the materials, and added sandy and gravelly material to the deposits; this sand and gravel had been examined by Prof. Boyd Dawkins, who found that it agreed in every particular with the glacial sand and gravel occurring in the valley a little way above. The large limestone blocks in the cavern had also been evidently disturbed by water-action; they were invariably found in the lowest deposits, and were covered over by laminated clay, sand, and gravels. The author considered it certain

that the caverns had been completely filled with these materials, and in the case of the Cae-Gwyn cave they appeared to have been conveyed mainly through the entrance recently discovered under the drift. The stratification at this entrance was so marked, and could be traced so continuously inwards over the bone-earth, that there could be no doubt that this was the main entrance. There was not the slightest evidence that any portion of the material had been conveyed in through a swallow-hole, and the conditions witnessed throughout were such as to preclude any such idea.

The author quoted a Report by Dr. Geikie, who considered that the wall of the cavern had given way, but before the deposition of the glacial deposits, which were subsequently laid down against the limestone bank so as to conceal this entrance to the cavern.

In conclusion, he referred to the presence of Reindeer remains in these caves, in conjunction with those of the so-called older Pleistocene mammalia, proving that these had reached the area long before the period of submergence, and evidently at an early stage in the Glacial period. It was important to remember that Reindeer remains had been found in the oldest river-gravels in which implements had been discovered. Man, as proved by the implements discovered, was also present at the same time with the Reindeer, and it was therefore natural to suppose that he migrated into this area in company with that animal from some northern source, though this did not preclude the idea that he might also have reached this country from some eastern or southern source, perhaps even at an earlier period.

Mr. De Rance, in an Appendix, confirmed Dr. Hicks's observations as to the identity of the deposits outside the cavern with those in its interior, and noted the occurrence of limestone blocks in the lower deposits, not merely at the spot where the supposed broken wall was situated, but also throughout the whole tunnel. He stated that the sand-bed forming the uppermost cave-deposit resembled the sand associated with gravels in a pit 400 yards east of the cave at a slightly higher level. The drift exposed in this gravel-pit he believed to be of the same age as that of the Mostyn and Bagillt pits to the north, which were undoubtedly overlain by Upper Boulder-clay. The westerly termination of the bone-earth outside the cave had not been determined, which he regretted; but traces of bone had been found at a point five feet from the overhanging ridge of the cave.

CORRESPONDENCE.

PALÆONTOLOGICAL NOMENCLATURE.

SIR,—The questions raised by the gentleman signing himself Rob. W. Haddow in the GEOL. MAG. for November, 1887, and discussed by Mr. S. S. Buckman in the March number, are well worthy of further consideration in your pages.

I confess that I largely agree with Mr. Haddow in his protest against the entire suppression of the old genus *Ammonites*, and I would reply to Mr. Buckman, (1) that the genera of one family

should differ from one another in characters of equivalent value, and (2) that it is *not necessarily wrong* "to include in the same genus species descended for a long time through entirely different lines of ancestors." There is in fact very little wrong or right in the matter, it is one of convenience and of sensible proportional treatment.

We may admit that the whole family Ammonitidæ requires revision and reconstruction, and possibly that it is desirable to create a certain number of new genera out of the old genus *Ammonites*, but I join Mr. Haddow in protesting against the infinite subdivision which some palæontologists are trying to force upon us. The old principles of classification may not be defensible, but is it so very certain that some of the principles now adopted in their stead, such as the form of the mouth, are any better? Is there not some analogy between the case of the genus *Ammonites* and that of the genus *Helix*, in which an infinity of peculiar variations occur in the shells without any important differences occurring in the structure of the animals?

If mere sections and subgeneric groups are raised to the rank of genera, the old genera become tribes and subtribes, and Mr. Buckman even wants us to accept names for generic and subgeneric groups, ranking between genera and subtribes. Surely, Sir, such an arrangement as he gives us in his Monograph on Inferior Oolite Ammonites is the height of cumbrousness, and shows the absurdity to which the system is capable of being carried. Stated in full this arrangement is as follows:—

Family—Ammonitidæ.
Subfamily—Ammonites (note the termination).
Tribe—Ægoceratidæ.
Subtribe—Harpoceratinæ.
Generic group—Hammatoceratidæ.
Generic subgroup—Hildoceratinæ.
Genus—Ludwigia.
Species—Murchisonæ.

Really I think a trinomial or even a quadrinomial system is better than this, which is practically a septinomial one. The small section of a group which is here elevated into a genus hardly merits a name at all, it is a mere section of *Harpoceras* which may be regarded as a subgenus of *Ammonites*. I therefore take up Mr. Buckman's challenge, and would speak of the species trinomially thus—

Ammonites (*Harpoceras*) *Murchisonæ*,
„ „ „ var. *obtusa*.

By this method it would still be possible for the stratigraphical geologist to speak of it as *Ammonites Murchisonæ*, while the palæontologist who makes a special study of the genus would doubtless usually call it *Harpoceras*; but no other Ammonite could receive the same specific name, whereas, if *Harpoceras* be admitted as a generic name, new species referable to that genus might receive the same names as those now applied to other well-known species of Ammonites; thus we might have *Harpoceras cordatus*, *H. cristatus*, etc.

As regards the rectification of erroneous identifications, we are of

course indebted to Messrs. Wright and Buckman for their researches, and if necessary the names of species taken to characterise given zones must be altered in accordance with their determinations. In no department has our nomenclature yet reached perfection, and as Mr. Buckman says, we must effect changes of name as our knowledge increases, but at the same time we must agree upon general systematic principles. A. J. JUKES-BROWNE.

SHIRLEY, SOUTHAMPTON.

GLAUCOPHANE IN ANGLESEY.

SIR,—The interesting paper by Prof. Blake, "On the Occurrence of a Glaucophane-bearing Rock in Anglesey," which appears in your March issue, suggests a question of nomenclature which is likely to give us some trouble. I am very glad to have Prof. Blake's support in assigning an igneous origin to some of the Anglesey schists; but now that they are schists I should hesitate to call them "igneous." In Prof. Bonney's description (quoted by Prof. Blake) of a specimen from the Anglesey column, the constituent minerals are "probably a species of chlorite," "epidote," "quartz (?)," and "mica"; and they form "a foliated dense felted mass." According to my view, in which I understand Prof. Blake to acquiesce, this rock was once a diorite (hornblende and plagioclase). If so, the change from the eruptive rock to the schist is surely entitled to be called a metamorphosis. If we apply the term "igneous" to a crystalline schist when we can assign to it an eruptive origin, must we call it "aqueous" when we know it was once a sediment? And under what head must we class it when its genesis is unknown to us? I grant that in tracing a diorite or a granite into a schist, we cannot fix a hard boundary-line between the two; but a similar difficulty meets us in the study of metamorphosed sediments, and it is not found to be very serious. However, I write rather to raise a question than to settle it. If we are not to call crystalline schists by the term "metamorphic," how shall we designate them? They would be as sweet to me by any other name.

WELLINGTON, SALOP. CH. CALLAWAY.

THE ATMOSPHERE OF THE COAL-PERIOD.

SIR,—In the review of the 2nd Vol. of my treatise on Geology which appeared in the last number of your MAGAZINE, your reviewer remarks (p. 161), "The author considers that, during the Coal-period, the atmosphere was more dense, and more charged with moisture and carbonic acid, and he is led 'to conclude that the coal-growth was in all probability one of extreme rapidity, and consisted of woods and plants containing a much larger proportion of carbon than any existing forest vegetation.' With regard to the excess of carbonic acid gas, Mr. Carruthers has expressed an adverse opinion, and experiments made on living plants have shown that they are liable to be poisoned, like animals, by an excess of the gas." A footnote to this passage refers to GEOL. MAG. 1869, p. 300, and 1871, p. 497. The first is a

paper "On the Forests of the Coal Period," in which he remarks that the plants "grew in extensive level plains. . . . The moist atmosphere (*not at all likely to have been charged with more carbonic acid gas than that of our own day*)[1] would encourage the growth of cellular parasites, etc." The second reference is to a paper by Dr. H. Woodward, "On Old Land Surfaces," in which, after quoting some remarks by Dr. Sterry Hunt to the effect that the atmosphere of the Coal period contained, as originally suggested by Brongniart, a "comparatively large amount of carbonic acid," he adds in a footnote, "Later experiments have, however, proved that plants, like animals, are at once poisoned by an excess of carbonic acid." Now the first reference appears to me only the expression of an opinion, and in the second, although experiments are mentioned, the reference is not given. I know of no such experiments, and if your reviewer or any of your correspondents can refer me to any, I shall feel very much obliged. The only experiments bearing on the subject, and which show that plants can live, flourish, and grow rapidly in an atmosphere with an excess of carbonic acid, I have quoted (p. 120), and I know of no others. Excuse the length of this letter, but I am anxious for information on this point, and should be glad of confirmation or otherwise on this subject, which is one of much theoretical interest.

DARENT-HULME, SHOREHAM, SEVENOAKS, *10th April*, 1888. JOSEPH PRESTWICH.

SPURIOUS FLINT IMPLEMENTS.

SIR,—Will you kindly allow me space in the GEOL. MAG. to inform its readers who may be collectors of Flint Implements, that there are at the present time being manufactured in London worked flints, which are stated to be genuine, but which are nothing of the sort, and at the same time to say that some of these manufactured flints have been sold to gentlemen for a high price, who are considered authorities on the subject, and I trust that should any of my readers meet with such as appear doubtful they will use their best endeavours to expose and stop such a fraud. GEO. E. EAST.

241, EVERING ROAD, UPPER CLAPTON, E.

ALPINE RIVERS AND BUNTER PEBBLES.

SIR,—Prof. Bonney's paper on the "Rounding of Alpine Pebbles" is a valuable contribution to a chapter of physical geology; but there are one or two considerations to which I do not think he has given sufficient recognition. (1.) Weathering of débris on the mountain-sides, which often gives a certain initial rotundity to fragments of rocks. (2.) The scouring action of sand in a mountain river. So far as I can recall my own Alpine observations, I am inclined to think that where the coarser detritus is most completely rounded, so that the pebbly form is generally produced, it has been in cases where a large proportion of sandy detritus was present also. On the other hand, I have generally found that at the mouths of

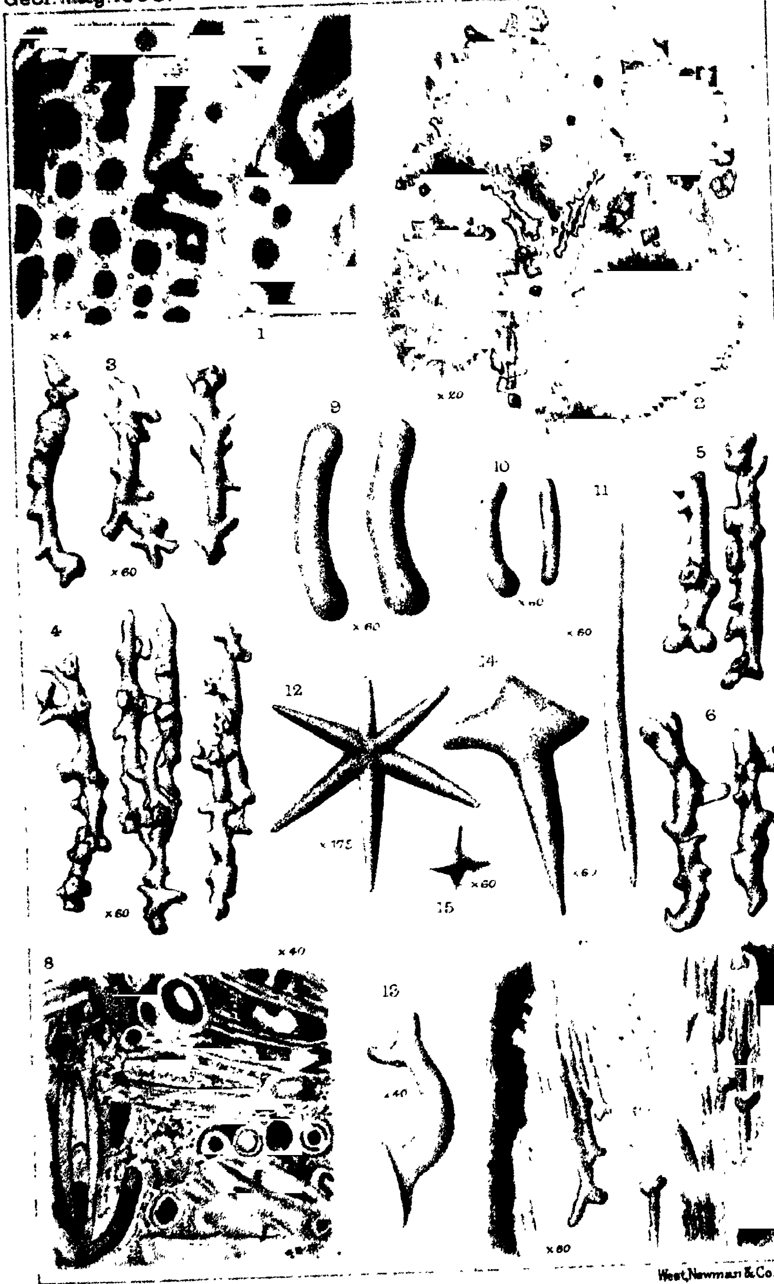
[1] The Italics are mine.

Alpine gorges where a stream has had a rapid descent, so that all, or nearly all, the sandy materials have been carried away and mutual attrition has been the chief agency called into play, the pebble-form has been the exception rather than the rule.

I look upon the *variety* of the contained fragments of the Bunter strata as one of their most important physical characters. This is not only true of such great pebble-deposits as the Budleigh Salterton Pebble-bed, and those of Sutton Park, near Birmingham; but it is even more marked in the Nottingham type of these beds, in which generally the facies presented to us is rather that of a *coarse pebbly sandstone* than that of a pebble-bed. In these we find very well-rolled pebbles of quartz and quartzite; but we also find fragments of such rocks as Millstone-grit, Coal-measure Sandstones, Yoredale Sandstones, Magnesian Limestones, along with occasional fragments and rolled masses of red Permian Marls, which, with those enumerated, can be traced to the denudation of the Pennine Highlands. These, together with the intercalated (often lenticular) marly bands formed in littoral pools, or in channels of contemporaneous erosion, are no doubt riverine in their origin; and, so far as I can recollect, are not generally worn into anything like pebbles. This certainly cannot be accounted for by their relative hardness. Facts of a similar nature in the Severn and Upper Trent country, and in Cheshire, have been recorded by Prof. Hull. I regard the strata of the Middle Bunter, where rolled detritus chiefly occurs, as a series of shore and bay deposits, in which riverine detritus from the ancient land is to be found mingled with pebbles (large and small), the latter owing their shape mainly to the action of a tidal surf and the scouring action of shore-sand. The occurrence of quartzite pebbles of Silurian rocks with (occasionally) casts of fossils of the French type (as recognized by Salter) in the Salterton pebble-bed (to the extent of something like 90 per cent.), the occurrence of similar pebbles with (occasionally) casts of Silurian forms in the Warwickshire Bunter, coupled with observations on *the work which Mr. Lee has actually done upon hard rock-fragments as they are driven along shore by the roll of a tidal surf* (*e.g.* between Clovelly and Westward-Ho), seem to me to tell rather of shore-action than of river-action as the main factor concerned in the production of the Bunter pebbles. The "pebbly sandstone" type of the Middle Bunter is that which represents the normal facies, the pebble-beds proper being quite local. The two types, however, pass laterally into one another; and the main factor concerned in their differentiation was probably the local trend of the shore-line in relation to the general direction of the tidal flow. Prof. Hull's memoir, "The Permian and Triassic Rocks of the Midland Counties of England," is a mine of facts which bear out this view.

A. Irving.

Wellington College, Berks.



F. C. Knight del. et lith. West, Newman & Co.

Spitzbergen Fossil Sponges.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. V.

No. VI.—JUNE, 1888.

ORIGINAL ARTICLES.

I.—On the Chert and Siliceous Schists of the Permo-Carboniferous Strata of Spitzbergen, and on the Characters of the Sponges therefrom, which have been described by Dr. E. von Dunikowski.

By George Jennings Hinde, Ph.D., F.G.S., etc.

(PLATE VIII.)

SHORTLY after the publication of my paper "On the Organic Origin of the Chert in the Carboniferous Limestone Series of Ireland," in the Geological Magazine[1] last October, my friend Prof. G. Lindström, of Stockholm, sent me a hand-specimen of cherty rock from the Permo-Carboniferous strata of Spitzbergen, which, on examination with a hand-lens, could be seen to be nearly entirely composed of spicules of sponges irregularly intermingled together, in the same manner as in the cherty beds of the Yoredale series in Yorkshire, Wales, and Ireland. This striking illustration of the organic origin of chert from a quite unexpected quarter induced me to inquire for further particulars of the nature and thickness of the rocks from which the specimen came, and Dr. A. G. Nathorst, of Stockholm, not only supplied me with the needful information which is given below, but further sent me a box of specimens of the rocks in question, which were for the most part obtained by the Swedish Expedition to Spitzbergen in 1882, under his leadership and that of the Baron de Geer. Prof. Lindström also sent for my examination most of the fossil sponges obtained by this same expedition, which have been described by Dr. v. Dunikowski;[2] and I propose in the present paper first to refer to the extent and the characters of the cherty rocks of Spitzbergen, and next to treat of the fossil sponges from them.

I may premise, however, that the specimens of cherty rock which I have examined have been in no wise selected on account of the presence in them of sponge-remains, since the origin of the rock from these organisms was not at all suspected at the time they were collected. The specimens were procured because they contain certain other fossils, such as Brachiopoda and Polyzoa, which have no special connection with the origin of the chert.

The following sketch of the stratigraphical divisions of the

[1] Dec. III. Vol. IV. pp. 435–446.

[2] Ueber Permo-Carbon-Schwämme von Spitzbergen, Kongl. Svenska Vetensk.-Akad. Handl. Bd. 21, No. 1, pp. 1–18, taf. ii. (1884).

Permo-Carboniferous series on the West and South-west shores of Spitzbergen has been kindly furnished to me by Dr. Nathorst. Some of the particulars were only obtained by the last Swedish Expedition. Dr. Nathorst makes four divisions in the series, which altogether is over 2000 m. in thickness. The lowest of these, which rests on red and green shales, regarded as Devonian, is the *Ursa sandstone,* which contains land-plants and corresponds to the European Culm or Scotch Calciferous Sandstone. In one locality, at Middle Hook in Bell Sound, Dr. Nathorst discovered in this division some intercalated marine deposits, consisting of dark schists with tracks of Annelids ("Fucoids"), Encrinital fragments, and a few siliceous Sponges.

2. *Cyathophyllum Limestone.* — This division comprises impure limestones with thin layers of chert and gypsum, also bituminous limestones with Corals, *Fusulinæ,* etc.

3. *Spirifer Limestone.*—From this division most of the fossils described from the Permo-Carboniferous series in Spitzbergen have been obtained, though it is not more than 10 mètres in thickness.

4. *Productus-chert.*—This division consists mainly of chert and siliceous rocks. Some of the beds are rich in *Producti* and other fossils, and are thus more or less calcareous; other beds are dark siliceous schists or shales, with a few Crinoidal remains and Polyzoa. It will be shown that the cherty beds are in places largely made up of the remains of siliceous sponges. Most of the fossil sponges yet known from Spitzbergen are from the lower beds of this division, which varies from 375 to 400 mètres in thickness.

A section of this division, exposed on the North Axel's Island in Bell Sound, was measured by de Geer in 1882, and the result has been communicated to me by Dr. Nathorst. It is of interest as showing the thickness of the different chert beds, and is reproduced below.

'Summit—Permian Shales, Marls, and Sandstones—300m.

		mètres.	
1.	Black siliceous schist	8·9	Productus-Chert Division.
2.	Black chert (? not exposed)...	5·1	
3.	Black ,, ...	22·0	
4.	Yellow ,, ...	12·5	
5.	Black ,, ...	12·8	
6.	Yellow ,, ...	21·4	
7.	Black ,, ...	23·2	
8.	Yellow ,, ...	71·9	
9.	Dark siliceous schist...	·9	
10.	Yellow chert...	25·8	
11.	Dark gray siliceous schist	·6	
12.	Yellow siliceous schist	47·8	
13.	Black ,, ,, ...	4·2	
14.	Yellow ,, ,, ...	46·3	
15.	Black ,, ,, ...	9·5	
16.	Yellow chert...	12·5	
17.	Dark ,, ...	14·0	
18.	Yellow ,, ...	4·2	
19.	Black ,, ...	58·5	
		402·1	

Owing to a slight dip in the strata, these measurements are a little in excess of the true thickness, which is estimated at 376m. Making this allowance, this division consists of 111m. of siliceous schists and 265m. or 870 feet of chert rock. The base of the division rests on the *Spirifer* limestone, whilst at its summit are the shales and marls of the Permian series, discovered for the first time by Nathorst and de Geer in 1882, the fossils in which, exclusively Permian in character, have lately been described by Prof. Lundgren.[1] The siliceous schists and cherts, therefore, known under the collective name of the Productus-chert division, constitute the summit of the Permo-Carboniferous series in Spitzbergen.

Most of the specimens of cherty rock forwarded to me by Dr. Nathorst are from the *Productus*-chert beds exposed on the eastern coast of Icefjord at Tempelberg and at Green Harbour and from Axel's Island in Bell Sound. The following are the salient characters of the principal specimens.

1. Specimens of white cherty rock at Templeberg, from near the summit of the Productus-chert and probably upon the same horizon at Angelinsberg, or Lovénsberg, in Hinlopen Strait. The rock is compact, of a greyish or milky-white tint, hard enough to scratch glass, and it gives in places slight ebullition with acid.

The Tempelberg specimens contain some grains of glauconite and quartz, but these are not present in the Hinlopen Strait example. The specimens also contain numerous shells and casts of *Productus*, and possibly also of *Spirifer*, the shells still retaining in part their normal structure of carbonate of lime. The matrix of the rock (if so it may be termed) in which these shells are imbedded, and of which their casts are composed, is a mass of closely-packed sponge spicules, chiefly linear or rod-shaped, either lying parallel to each other, or more frequently crossing one another irregularly (Pl. VIII. Fig. 8). These spicules are of chalcedonic silica; in microscopic sections by transmitted light they show an outer ring of a brownish yellow tint, whilst the central or axial portion is either of transparent silica, or of an opaque material. In some parts of the Hinlopen specimen the spicules gradually pass into a nearly pure translucent chert, in which their forms have, for the most part, disappeared, and only the solid casts of their axial canals can be distinguished.

The spicules in these rock-specimens are generally imperfect and fragmentary; the only recognizable forms are small curved cylinders with slightly inflated extremities (Pl. VIII. Fig. 9), similar to those of *Reniera clavata*, Hinde, which are very common in the cherty sponge beds of the Yoredale Series of Yorkshire and North Wales (Brit. Pal. Sponges, pt. ii. p. 143, pl. ix. figs. 5 *a*, *b*, Pal. Soc. vol. for 1887). Most of the detached spicules are apparently simple monaxial forms, and may perhaps belong to monactinellid sponges. Dr. Nathorst informs me that the bed of white chert at Tempelberg is only about three feet in thickness, but that further to the north-east it gradually

[1] Anmärkningar om Permfossil från Spetsbergen; Bihang till K. Svenska Vet. Akad. Handb. Bd. 13, Afd. iv. No. 1, pp. 1-26 (1887). *Cf.* Geol. Mag. March, 1888, p. 131.

increases in thickness. The thickness of the white chert bed in Hinlopen Strait is not known. No corresponding bed of white chert occurs in the section at Axel's Island.

2. Specimen of bluish chert from Bell Sound, probably from Axel's Island. This is a hard, brittle rock, with a splintery fracture; it gives no action with acid. It contains the mould of a large Brachiopod. The surface in places is covered with the impressions of slender elongated spicules, but in the interior of the specimen only the axial portions of the spicules remain. This specimen is precisely similar in appearance and character to the cherty rocks of the Yoredale Series in Yorkshire, and could not be distinguished from them.

3. Specimen from the *Productus*-chert at Green Harbour, Icefjord. This is a dark, siliceous rock, with *Producti*, Polyzoa, and probably small Corals. The cells of these organisms have been infilled with siliceous material, and their walls have been weathered away on the surface; the *Productus* shells are, in part, replaced by silica. No spicules can be determined on the outer surface of the rock, but they can be seen in a thin section. Amongst the monactinellid spicules there is a cruciform spicule belonging to a hexactinellid sponge (Pl. VIII. Fig. 15).

4. Specimen from the *Productus*-chert from South Axel's Island. This is a hard, dark, siliceous schist, containing fragments of the problematical fossils known as *Taonurus* or *Spirophyton*. It appears mainly to consist of very minute subangular quartz grains in a dark cement. There are scattered in the rock numerous minute cylindrical spicules, similar to those of *Reniera bacillum*, Hinde, from the Yoredale Series of Yorkshire and North Wales (Pl. VIII. Fig. 10). Frequently the spicules occur as hollow casts or partially replaced by iron rust.

5. Specimens of dark siliceous schists from the *Productus*-chert division of South Axel's Island and Middle Hook in Bell Sound. These rocks, like the preceding, are mostly made up of minute subangular grains of quartz and a varying amount of calcite. Thin sections show a few spicules in places, but they are insufficient to affect the character of the rock.

6. Nodular masses of chert intermingled with crystalline calcite from Cape Wijh. The chert in these specimens is nearly translucent, and shows but little structure. It contains traces of spicules and Foraminifera.

7. Dr. Nathorst has also forwarded to me a smooth rounded pebble of chert, from the gravels of Nordenskiöld's Berg, which are of Tertiary age, with the view of ascertaining if its minute structure corresponded with that of flints from the Chalk, which, in outward appearance, it much resembles. A microscopic section of the pebble showed that it was composed of chalcedony and crystalline silica, and that it is filled with the remains of spicules which are now for the most part only represented by the infilled casts of their axial canals; in some instances, however, the spicules consist of an opaque material. They are chiefly fragments of rod-shaped forms, but amongst them are fusiform, acerate, and also lithistid spicules, closely

resembling those of *Doryderma Dalryense*,[1] H. (Pl. VIII. Fig. 13), from the Carboniferous of Ayrshire, and minute hexactinellid spicules (Pl. VIII. Fig. 12). Both the forms of the spicules and the mineral structure of the rock point to the conclusion that the pebble has been derived from some of the cherty sponge-beds of the Permo-Carboniferous series.

The character of these chance fragments from the *Productus*-chert division of the Permo-Carboniferous series distinctly shows that the chert beds in this division are largely composed of the detached spicules of disintegrated siliceous sponges, and thus of organic origin in the same manner as the chert-beds in the Yoredale Series of Yorkshire, North Wales, and Ireland. Not only is the general character of the rock extremely similar, but in some instances the same forms of spicules are present in the Spitzbergen, as in the British rocks. The dark siliceous schists, on the other hand, intercalated between the cherts, are chiefly composed of minute grains of quartz, and thus merely of sedimentary origin, but in some of these sponge spicules are also numerously represented. It is true that the number of specimens of chert available for examination is very few, and they might be regarded as insufficient of themselves to warrant the conclusion that this great thickness of rock, which at one locality on Axel's Island reaches 870 feet, is due to the accumulation of the skeletal débris of siliceous sponges; but taking into consideration the fact that beds of similar cherty rock, which in Yorkshire[2] have an estimated thickness of 90 feet, and in North Wales of 350 feet, can be proved to be due to sponge remains, there is nothing extravagant in the supposition that this much greater thickness of rock has had a similar origin. It is reasonable to suppose, moreover, that if specimens collected indiscriminately thus show their derivation from sponge remains, still stronger evidence would be obtainable if search were specially made for it.

So far as I am aware, the Spitzbergen chert beds have never been specially studied; the principal notice of them which I have seen is by Baron A. E. Nordenskiöld,[3] who writes of them in 1876 :—"In Ice and Bell Sounds, as well as in Hinloopen, the *Spirifer* Limestone and gypsum are covered by a statum of impure limestone rich in silica, or by a black flint extraordinarily rich in fossils, especially in *Producti* of large size and with large shells. Within this division the flint strata of silica are scarcely ever of the nature of sandstone, but form beds, several hundred feet thick, consisting of a nearly pure flint, and I think it highly probable that the formation of these immense flint beds stands in connexion with the eruptions whence originated the massive layers of plutonic rocks which meet us everywhere on Spitzbergen, and which in many places form the very boundary between the Mountain Limestone and the overlying strata belonging to later formations." From this it would appear that an

[1] British Fossil Sponges, pt. i. pl. v. fig. 7*b*, Pal. Soc. vol. for 1886.
[2] British Palæozoic Sponges, pt. ii. Pal. Soc. vol. for 1887, p. 100.
[3] Sketch of the Geology of Ice Sound and Bell Sound, Spitzbergen, Geol. Mag. Dec. II. Vol. III. 1876, p. 66.

organic origin of the chert, or flint as it is termed, is not even suspected, but it is supposed to have an undefined relation to igneous[1] rocks. But in the section measured by Geer on Axel's Island the chert and siliceous schists form an uninterrupted series of strata, 376 mètres in thickness, without volcanic materials, nor do such occur in the Permian strata overlying them.

The fact is not without significance that the geological horizon on which this enormous series of cherty rocks in Spitzbergen occurs corresponds approximately with that in which rocks of a similar character are so largely developed in the British Isles. The Carboniferous chert beds in Britain mainly appear in the upper portion of the *marine* Carboniferous series, between the true Mountain Limestone and the Millstone Grit. In Spitzbergen, also, they form the upper portion of a series of rocks regarded stratigraphically as the equivalents of the Carboniferous Limestone, even though they contain a certain admixture of Permian fossils. In Spitzbergen, however, the grits, sandstones, and coal-bearing beds, which succeed the Yoredale rocks in this country, are not represented, and the Permo-Carboniferous cherts are directly followed by shales, marls, and sandstones, containing an exclusively Permian Fauna.

II. On the Fossil Sponges from Spitzbergen described by Dr. E. von Dunikowski.

The cherty rocks of Spitzbergen, unlike those of Yorkshire and North Wales, have yielded entire forms of sponges, in addition to the detached spicules thickly scattered through the rock itself. These sponges were discovered by the last Swedish Expedition under Nathorst and de Geer, most of them in the dark siliceous schists of the *Productus*-chert series of Axel's Island; some were also obtained from the *Cyathophyllum* limestone of Templeberg and Gypshook, and from the *marine* beds of the Ursa sandstone at Middlehook in Bell Sound. The specimens were entrusted to Dr. E. von Dunikowski for description, who prepared microscopic sections from them, and described them as a new genus of monactinellid sponges under the name of *Pemmatites*, including within it the following species: *P. verrucosus*, *P. arcticus*, and its two varieties, *macropora* and *latituba*.

The characters assigned to the genus appeared to me so peculiar, that at my request Prof. Lindström kindly forwarded to me most of the type-specimens, and the microscopic sections from them, for examination, as well as an additional specimen of *P. arcticus*, var. *macropora*, which had not been submitted to Dr. Dunikowski, from which, and from another specimen, I have had further microscopical sections prepared. As the results of my study of these type-specimens I have arrived at conclusions as to their characters so widely

[1] A somewhat similar origin was attributed to a band of flinty or horny rock in the Carboniferous Limestone of Glencart, Dalry, Ayrshire, by my friend Mr. John Young, F.G.S., who regarded the silica as deposited chemically by heated waters from springs connected with volcanic vents in the neighbourhood (Proc. Nat. Hist. Soc. Glasgow, April 25, 1882, p. 237). Since hearing my paper on the organic origin of the Irish Carboniferous chert, Mr. Young examined sections of this flinty band under the microscope, and he has informed me that it is crowded with minute sponge-spicules, so that no doubt of its origin from these organisms can be entertained.

different from those of Dr. Dunikowski, that it will be necessary for me to state in some detail the structural features on which they are founded.

Little requires to be said of the outer form of the Sponges. They are in some cases flattened or discoid bodies, with circular, oval, or irregular outlines, in others nearly round, and, as is so frequently the case with the Palæozoic sponges, they show no stem or surface of attachment. Their exterior surfaces are usually uneven, with blunted warty eminences irregularly dispersed over them. Under favourable circumstances the surface also exhibits between the elevations a reticulation or network of siliceous translucent fibres, bounding circular or subpolygonal interspaces of a dark appearance.

The sponges are now compact throughout; in sections or fractured surfaces they exhibit a mesh of the translucent siliceous fibres, some of which have a generally radial direction from the central portion to the surface of the sponge, whilst others run transversely, and unite with the radial fibres, and thus form a connected meshwork, the spaces between which, as at the surface, are of a dark mineral (Pl. VIII. Figs. 1, 2). The sponges are now mostly of silica, but in all the specimens examined there is a slight reaction with acid.

In microscopic sections the *dark* portion of the sponge is seen to consist chiefly of minute particles and rods of an opaque material, probably of carbonaceous, though some may be of ferruginous origin, imbedded in a lighter granular (?) matrix; in this, also, are rod-shaped or acerate siliceous spicules, disposed quite irregularly both with respect to each other and to the direction of the interspaces in which they occur. Further, the spicules are by no means uniform in shape or in size in the same specimen, or in the same portion of it. There is every probability that, as suggested by Dunikowski, the dark rods mentioned above are merely replacements of siliceous spicules.

The translucent siliceous fibres of these sponges, when seen in microscopic sections, are either colourless or of a yellowish tint, their margins are uneven, they consist of fibrous radiating chalcedonic and crystalline silica, which gives brilliant tints between crossed Nicols. In this ground-mass there are frequently microscopic crystals of calcite, and here and there elongate rod-like spicules with stumpy lateral projections (Pl. VIII. Fig. 2). These spicules are frequently isolated in the fibres, their length corresponding with the direction of the fibre; occasionally several occur together closely united, evidently in their natural positions, by the apposition of their blunt projections to the surfaces of adjoining spicules (Pl. VIII. Fig. 4). They have the same general characters, and the same mode of union with each other as the spicules of lithistid sponges. Though, as a rule, only a few of these spicules now remain in the translucent fibres, their outlines are, for the most part, peculiarly distinct, and, strangely enough, though there can be no doubt that they are the spicules of siliceous sponges, and they are at present imbedded in a siliceous ground-mass, yet they are now chiefly composed of clear calcite. The fact is of importance also, that though there are plenty of acerate and smooth

rod-shaped spicules in the dark portion of the sponge, none of these forms can be seen in the translucent fibres, and, similarly, the lithistid spicules of the fibres do not occur in the dark interspaces. There is further a general uniformity in the character of these lithistid spicules, not only in the same specimen, but in those of distinct species.

Dr. v. Dunikowski attaches, in his paper, but little significance to these lithistid spicules.[1] He does indeed mention the occurrence of a few nodose irregular lithistid spicules with some of tetractinellid origin, but he thinks they have probably nothing to do with the proper skeleton of the sponges, but should be considered as merely accidentally introduced forms. I find, however, that they are very generally present in the translucent fibres of the sections[2] prepared and studied by this author.

Dr. v. Dunikowski considers that the dark portions of these sponges, which form, as already mentioned, the irregular interspaces between the translucent anastomosing fibres, are the true skeletal fibres, and the acerate spicules imbedded in them irregularly, as the monactinellid spicules proper to the skeleton. The translucent connected portions, on the other hand, which in this paper I have denominated fibres, are described by this author as the original canals of the sponge, which, after the death of the animal, have been infilled with crystalline quartz free from any admixture of those foreign substances which have given such a dark appearance to the rest of the sponge. These so-termed canals are described as main canals, and concentric or connecting canals.

My interpretation of the characters of these sponges totally differs from that of Dr. Dunikowski, for, in my opinion, the translucent anastomosing fibres—the "canals" of Dunikowski—are in reality the fibres of the sponge which were originally composed of lithistid spicules. Most of these have been dissolved, and their spaces filled with chaceldony and quartz; some remain, either singly or united in their natural positions in the fibres. The dark portions of the sponge—the "skeletal fibres" of Dunikowski—I regard as merely the irregular interspaces between the true skeletal fibres, in which the water circulation was carried on during the lifetime of the animal, and which after its death became infilled with the materials of the sea-bottom, consisting of a fine siliceous mud, with numerous spicules, chiefly of disintegrated monactinellid sponges, dispersed through it.

In support of my view, I may state that fossil lithistid sponges, in which the fibres have been replaced in a similar manner to these Spitzbergen forms, are of not unfrequent occurrence. I have before me microscopic sections of *Aulocopium* and *Astylospongia* from the Silurian strata of Gotland, in which the process has taken place; and, in one instance, the lithistid spicules are now of calcite, imbedded in a chalcedonic matrix, under the same circumstances as those of *Pemmatites*.

[1] *Loc. cit.* p. 7.

[2] They are present in seven out of ten slides of *P. arcticus*, in both of the slides of *P. verrucosus*, in two out of three slides of the var. *macropora*, and in two out of three slides of the var. *latituba*, which were sent to me by Prof. Lindström.

The dark portion of the sponge, which I regard as infilled material from the sea-bottom, is clearly of the same nature as many portions of the rock-matrix, which show in microscopic sections dark granules, rod-like bodies, and spicules of various forms interspersed in a siliceous matrix. It is quite in accordance with our experience of fossil sponges—and of recent forms as well—to find their canals and interspaces between their skeletal fibres filled with a varied assortment of spicules, often of a character quite different from those proper to the sponge itself. Further, in one of the Spitzbergen specimens the supposed canals are distinct cylindrical siliceous fibres, whilst the dark portion—the supposed skeleton—hardly shows traces of spicules, and passes uninterruptedly into the surrounding rock-matrix, and cannot be distinguished from it.

On Dunikowski's view that the siliceous fibres were originally canals, it is difficult to account for the presence in them of lithistid spicules exclusively, and it is equally as difficult to imagine that whilst foreign spicules and other materials were accidentally introduced into what are stated to be the skeletal tissues, none should have found their way into what are stated to have been the empty canals of the sponge.

But the most convincing evidence that the translucent portions in these sponges are, in reality, the skeletal fibres, and not the canals, is afforded by sections, prepared by v. Dunikowski, of a specimen from the *Cyathophyllum* limestone of Gypshook. The translucent portions in these sections are in places filled with the original spicules, running parallel with each other, and evidently in their natural position in the fibre. Unfortunately the outlines of these spicules have been rendered very indistinct by the fossilization, so that their complete forms cannot be made out definitely, and they appear to differ from the typical forms of *Pemmatites* in being furcate at one or both ends (Pl. VIII. Fig. 7). Unlike the specimens from Axel's Island, the spicules in these sections are not replaced by calcite, but consist of chalcedonic silica. The dark portions in these sections do not contain many spicules, and no doubt can be felt that they are simply the rock-matrix. The sections are named by Dunikowski, *P. arcticus*, var. *latituba*, but it is probable, judging from the form of the spicules, that the sponge is generically distinct from *Pemmatites*.

The grounds above stated appear to me to justify the view that these Spitzbergen sponges are really lithistid and not monactinellid forms. On this interpretation the diagnosis of the genus given by Dunikowski requires to be fundamentally altered; but as the term *Pemmatites* has reference to the outer form of the sponges merely, and no bearing on their inner structures, there is no reason why it should not be retained with the amended description as below:—

Order: Silicispongiæ.
Suborder: Lithistidæ.
Family: Rhizomorina.
Genus: *Pemmatites*, v. Dunikowski, emend. Hinde.
1884, Kongl. Svenska Vet.-Akad. Handl. Bd. 21, No. 1, p. 13.

Discoid, compressed or globular, sponges, apparently without stem or surface of attachment. The skeleton consists of a meshwork of subcylindrical anastomosing fibres, which are composed of rod-shaped lithistid spicules with blunted and facetted lateral processes. The open spaces between the fibres form an indefinite canal-system, with circular or polygonal apertures at the surface of the sponge.

I do not propose here to enter upon the detailed descriptions of the species and varieties given by Dunikowski, which appear to me to be substantially correct as regards the measurements and other particulars relating to the form and direction of the fibres, etc., but I may remark that in referring to them we must bear in mind that the structures described as canals are the skeletal fibres, whilst the so-termed fibres are only the interspaces between the real fibres, now infilled with matrix. Examined from the new point of view, the sponges described as varieties *macropora* and *latituba* (*loc. cit.* pp. 15, 16) appear to be sufficiently distinct from *P. arcticus* to be considered as separate species.

The lithistid spicules in these sponges, as shown by the accompanying figures (Pl. VIII. Figs. 3–6), vary somewhat in size and form; for the most part they consist of a straight or slightly curved rod-like axis, truncated or obtusely pointed at the ends, with short lateral projections terminating in minute facets.[1] They vary from ·4 to ·6 mm. in length, and about ·06 mm. in thickness.

I have not been able to detect a dermal layer (Deckschicht) as distinct from the fibres, in any of the sponges; the structure so named and figured by Dunikowski appears to me to be merely a thin layer of matrix incrusting the surface of the sponge.

Whilst thus differing from Dr. Dunikowski as to the interpretation of the structure of these sponges, I wish to bear testimony to the very careful manner in which he has investigated and described their characters. The specimens are in a very unfavourable state of preservation, and owing to the very complicated changes which take place in the fossilization, it is, without special experience, easy to make a mistake in determining the original characters of these organisms from the older rocks.

Summary.

Specimens of chert-rock from the *Productus*-chert division of the Permo-Carboniferous series of Spitzbergen are shown to consist largely of detached siliceous sponge spicules, thus indicating the probable derivation of this rock from the skeletal remains of these organisms. The chert is of the same character as that of the Yoredale beds of the British Isles, and it occurs on the same relative geological horizon. The *Productus*-chert division has a thickness on Axel's Island of 376 m., of which 265 m. are chert, and 111 m. dark siliceous schists, likewise containing sponge remains, but less abundantly than the chert. The chert had previously been regarded as connected in some way with the igneous rocks of the island.

[1] As already mentioned, the spicules in *Pemmatites latituba* differ in form, and they are more slender than in the other species described.

The Sponges obtained from these rocks, which had been described as Monactinellid forms by v. Dunikowski, are shown to be really Lithistid sponges, this author having mistaken the original fibres for canals, and the infilling matrix, in which detached spicules occur, for the fibrous skeleton of the sponge.

EXPLANATION OF PLATE VIII.

FIG. 1. Part of a vertical section of *Pemmatites macropora*, Dunik., showing the disposition of the translucent skeletal fibres and the dark matrix. Enlarged four diameters. From the *Productus*-chert beds of the Permo-Carboniferous series, Bell Sound, Spitzbergen.

„ 2. Part of a section from the same specimen, enlarged twenty diameters, showing lithistid spicules in the translucent fibres, as well as crystals of calcite.

„ 3. Detached spicules from the same section, enlarged sixty diameters.

„ 4. Spicules from the same, showing their mode of union with each other. Enlarged sixty diameters.

„ 5. Two detached spicules occurring in the translucent fibres of *Pemmatites arcticus*. Enlarged sixty diameters. Drawn from a section prepared by v. Dunikowski.

„ 6. Two spicules from the translucent fibres of *P. verrucosus*, Dunik., similarly enlarged. Also from one of Dunikowski's sections.

„ 7. Part of a section of *P. latituba*, Dunik., from the *Cyathophyllum*-limestone at Gypshook, Bell Sound, showing spicules (now partially obliterated) in the translucent fibres. Enlarged sixty diameters. Drawn from a section prepared by v. Dunikowski.

„ 8. A section of the White Chert from Templeberg, Spitzbergen, showing its structure of sponge-spicules irregularly intermingled together. Enlarged forty diameters.

„ 9. Two detached cylindrical spicules of *Reniera clavata*, Hinde, from the White Chert of Templeberg. Enlarged sixty diameters.

„ 10. Detached cylindrical spicules of *Reniera bacillum*, Hinde, from a section of the *Productus*-chert at South Axel's Island. Enlarged sixty diameters.

„ 11. A fusiform acerate spicule from a section of a chert pebble (probably from the Permo-Carboniferous), from the Tertiary gravels of Nordenskiöld's Berg. Enlarged sixty diameters.

„ 12. Flesh spicule of hexactinellid sponge from the same pebble. Enlarged 175 diameters.

„ 13. Lithistid spicule of *Doryderma Dalryense* (?), Hinde, from the same pebble.

„ 14. 15. Modified hexactinellid spicules. Enlarged sixty diameters. From Axel's Island and Green Harbour, *Productus*-chert series.

II.—NEW PALÆONISCIDÆ FROM THE ENGLISH COAL-MEASURES. No. II.

By DR. R. H. TRAQUAIR, F.R.S., F.G.S.

(For No. I. see GEOL. MAG. Dec. III. Vol. III. 1886, p. 440.)

Elonichthys Binneyi, sp. nov., Traquair.

OF this I have seen only two specimens. One of them, slightly longer than the other, measures 3½ inches in length up to the commencement of the caudal fin, which is deficient in both; the greatest depth of the body 1½ inch, the length of the head nearly the same. The dorsal fin is opposite the interval between the ventral and the anal; both dorsal and anal are triangular acuminate in shape, with delicate rays which at first are somewhat distantly articulated, the joints being ornamented with one or two longitudinal sulci. The pectorals are not seen in either specimen, but the smaller of the two shows a well-preserved ventral, which is pretty large, and acuminate in shape.

The scales are best seen in the smaller specimen, and are rather large for the size of the fish, one from the middle of the flank measuring $\frac{3}{16}$ inch in height by $\frac{1}{16}$ in breadth. Over most of the body they are higher than broad, but behind the dorsal fin they become more equilateral and obliquely rhomboidal. The anterior covered area is very narrow; the sculpture of the exposed part is peculiar, and different from that in any other Carboniferous Ganoid with which I am acquainted. Taking one of the flank scales, its external glittering surface is ornamented by delicate wrinkles, a few of which run parallel with the anterior margin, while behind these and over the greater part of the surface they run in an antero-posterior direction, ending in delicate denticulations of the hinder margin; anteriorly, however, these transverse ridges and furrows do not run parallel with each other, but tend to converge in two or three groups. This ornament becomes less marked in the scales behind the dorsal fin, the vertical striæ disappearing, and the scale appearing marked only with a few irregular horizontal furrows; the delicate denticulation of the posterior is, however, preserved as far as the tail-pedicle, where the specimen is broken off.

Remarks.—The form of the scales, and the structure and position of the ventral, dorsal, and anal fins, induce me to class this little fish as an *Elonichthys*, though unfortunately the character of the dentition, and the form of the pectoral fin are unknown, while the bones of the head are not in a condition to be described. As a member of this genus it is distinguished by its rather slender form, and proportionally large scales, with their peculiar ornament.

Geological Position and Locality.—From the Dalemoor Rake Ironstone, Lower Coal-measures, Stanton, Derbyshire, where it is associated with *Elonichthys Aitkeni*, Traq.; *Platysomus tenuistriatus*, Traq.; and *Mesolepis micropterus*, Traq. The two specimens which have served for the above description are in the collection formed by the late Mr. E. W. Binney, of Manchester, who lent them to me some years before his death. The notes, taken of them at that time, are now for the first time published, and the drawings will appear in the continuation of my Monograph on the Carboniferous Ganoid Fishes of Great Britain.

Gonatodus Molyneuxi, Ward, sp. MS.

The largest specimen of this little fish which I have seen is scarcely more than three inches in length; the shape is fusiform, rather "stumpy"; the length of the head is contained about $4\frac{1}{2}$ times in the total. Cranial roof bones ornamented with closely placed, contorted, thread-like ridges; jaws armed with apparently one row of comparatively stout stylo-conical bluntly-pointed teeth, which are slightly incurved towards the apex. Scales proportionally large; covered surface narrow; exposed surface, in the flank scales, marked in front with a few exceedingly delicate vertical grooves or striæ turning round below parallel with the lower margin, the rest of the surface being marked posteriorly with nearly equally minute transverse striæ ending on very delicate denticulations of the hinder

margin—a nearly smooth space being left between the last set of striæ and the vertical ones along the front. The scales become smaller and more oblique posteriorly, the striation fading away, though the marginal denticulation remains as far back as the caudal fin.

The fins are not very well preserved in any of the specimens I have seen. The pectorals are not visible; the dorsal is nearly opposite the interval between the ventrals and the anal; the caudal is of course heterocercal. All seem to be rather few-rayed; rays comparatively coarse with distant articulations, the joints being smooth, or ornamented with one or two delicate sulci.

Remarks.—This well-marked species was discovered, and recognized as undescribed, by Mr. Ward, F.G.S., of Longton, who confided to me the specimens for description, with the request that I would name it *Molyneuxi*, after his friend, the late Mr. Molyneux, well known as a collector of North-Staffordshire Carboniferous fossils. It is the same fish which in my essay on the structure of the Palæoniscidæ I alluded to as *Microconodus Molyneuxi*, and only the desire to avoid excessive multiplication of genera induces me to withdraw "*Microconodus*" for the meanwhile. The species has undoubtedly certain obvious resemblances to the common Lower Carboniferous genus *Gonatodus*, but the teeth do not seem to exhibit that second flexure at the apex so characteristic of at least the type species *G. punctatus*, Ag. sp. From the Lower Carboniferous species of the genus it is furthermore distinguished by the greater comparative size of the scales and the coarseness of the fin rays.

Geological Position and Locality. — Deep-Mine Ironstone, Coal-measures, Longton, Staffordshire. In the Collection of Mr. Ward.

Rhadinichthys Planti, sp. nov. Traquair.

The most perfect specimen I have seen measures $2\frac{1}{8}$ inches in length by $\frac{7}{20}$ in greatest depth; its shape is therefore elegant and slender. The head measures $\frac{9}{12}$ inch in length, and is contained nearly 5 times in the total; the dorsal fin commences $1\frac{1}{4}$ inch behind the tip of the snout, and the lower lobe of the caudal $1\frac{3}{4}$ inch behind the same point, the anal being exactly opposite the dorsal. The pectorals are not exhibited in any specimen I have seen, but traces of a ventral are seen in one case midway between the anal and the shoulder-girdle.

The head shows a *peculiarly large development of snout*, forming a considerable bluntly-pointed prominence over the mouth. The cranial roof bones are ornamented with incised furrows, producing a comparatively coarse flattened ridging between them. The suspensorium is oblique, the operculum is broad, but with its inferior margin sloping obliquely upwards so as to make an acute angle with the anterior, and an obtuse angle with the posterior one. Correspondingly the superior margin of the suboperculum slopes very obliquely upwards and backwards, its anterior margin is short, and the posterior one long and rounded. The upper limb of the

preoperculum is broad and triangular, the lower one narrow. I see no markings on these opercular bones save a few concentric striæ. The maxilla is of the ordinary palæoniscoid shape, but in none of the specimens are its markings clearly shown. The mandible is comparatively short, and is ornamented by prominent ridges which run obliquely forward so as to touch the upper or dentary margin at very acute angles.

The scales are small, rhombic, and with the usual palæoniscoid mode of articulation. It is extremely difficult accurately to make out the character of the outer surface, which seems to be ornamented with excessively minute and faintly marked ridges and furrows, bearing obliquely downwards and backwards over their surface.

Remarks.—I place this strange little Palæoniscid, whose specific characters are so strongly marked, only provisionally under *Rhadinichthys*; and probably a new genus will ultimately have to be established for it, characterized by the more than usually prominent snout and the dorsal being exactly opposite the anal fin, characters in which I must own it differs from the typical species of *Rhadinichthys.*

Geological Position and Locality.—Coal-measures. The best specimens I have seen are in the collection of Mr. John Plant, of the Royal Museum, Salford, who obtained them from Colleyhurst near Manchester; others, less perfect, are in the collection of Mr. Ward, of Longton, who collected them from the Deep-Mine Ironstone of that locality. Burnley, Lancashire, collected by Mr. G. Wild.

I have pleasure in naming this species after Mr. Plant, who has always been most liberal in affording me access to the specimens of Coal-measure Fishes in his collection.

Acrolepis Wilsoni, sp. nov., Ward, MS.

Exposed surface of scale $\frac{5}{8}$ inch in height by $\frac{7}{24}$ in breadth: rhombic, closely covered with small pits about $\frac{1}{14}$ inch in diameter, which in the middle of the area are arranged quite irregularly, but above and below are disposed in three or four regular lines parallel with the upper and lower margins respectively. The surface between the pits is minutely fretted with excessively delicate grooves, only perceptible by aid of a lens.

The well-developed covered area projects upwards in an angular process, the articular spine is strongly marked.

Remarks.—The scale described above was collected by Mr. E. Wilson, F.G.S., from the Yoredale Shales of Turnditch, near Belper, Derbyshire, and recognized as new by Mr. Ward, of Longton, through whose intermediation it came into my hands for description.[1] The shape of the scale indicates *Acrolepis* as its genus, but the pecularity of its markings entitles it to specific distinction, and accordingly, at the request of Mr. Ward, I name it *Acrolepis Wilsoni.*

[1] Since the period here referred to, the scale has come into the possession of the British Museum.

III.—On a Limestone with Concentric Structure from Kulu, North India.

By C. Davies Sherborn, F.G.S.

In the Thirty-Sixth Annual Report on the New York State Museum of Natural History (8vo. Albany, 1884), is a folding plate with a fly-leaf descriptive of a specimen with peculiar structure from the Calciferous Sandstone group of Greenfield, Saratoga Co. It is referred to a new genus and species under the name of *Cryptozoon proliferum*,[1] but no author's name appeared to either the plate or the description.[2] The peculiar appearance of the American figure reminded Prof. Rupert Jones of a specimen in his collection, and having kindly placed it in my hands and permitted me to bring it before the notice of the readers of the Geological Magazine, he has given it to the British Museum. Prof. Jones's specimen was collected by the late John Calvert, F.G.S., the author of "Vazeeri Rupi, the Silver Country of the Vazeers in Kulu,"[3] and the rock is referred to at p. 8 of that book. The specimen was shown by Mr. Calvert to Sir Warington W. Smyth (whose opinion as to its inorganic nature is quoted by Mr. Calvert), and afterwards given to Prof. Jones. At first sight it very much resembles the figures of the American fossil. It consists of an oblong slab, 4 × 2½ × 1 ins., showing in its centre a round or rather oval concretion, the matrix being dark slate-coloured limestone, similar in general appearance to our Carboniferous Limestone. One face of the slab has been cut through the centre of the round mass and the other face half-way between the centre and the periphery. The concentric structure occupying nearly the whole of the surface of the slab (as may be seen in the accompanying Figure) touches one side; and only the corners of the slab show the undisturbed bluish matrix. The rings are of many shades of grey, with a few of an orange-pink colour passing into brown. On two sides of the face of the slab are indications of other concentric masses, and with one of these the example in question appears to have been joined, as it shows a tendency to assume a pear shape, with a "point below" the root or starting-point of growth—as in the description of the figures of the American form.

It seems certain that the American specimens are of organic origin, for we are told that "the substance between the concentric lines in well-preserved specimens is traversed by numerous, minute, irregular canaliculi, which branch and anastomose without regularity," and that "the central portions of the [concentric] masses are usually filled with crystalline, granular, and oolitic material, and many specimens show the intrusion of these extraneous and inorganic substances between the concentric laminæ." In the Indian specimen

[1] Since this paper was written and handed in to the Geol. Mag. another note on *Cryptozoon* has been published in the 14th Ann. Rep. Geol. N.H. Survey, Minnesota, for 1885, 8vo. St. Paul, 1886.

[2] The authorship of this paper has been referred to Dr. James Hall, of Albany.

[3] 8vo. London and New York, 1873.

there are neither of these evidences; but the last few regular rings—of a pale ash-grey colour—are crowded with straight or slightly curved fibre-like markings, rarely bifurcating, sometimes solitary and sometimes in bundles. They are indicated by white linear streaks, and under the microscope are seen to be minute cracks through the layers. They do not radiate from the centre of the mass, and are apparently quite independent of the original crystallization; for in some instances they are tangential to the series of rings. In some of the darker rings, radial crystallization is well marked, round the outer edge, and we can see distinctly that such layers would, if their

Section of a concentric mass, probably of organic origin, imbedded in dark-coloured limestone, from Kulu, Central Himalayas.

surface were exposed, exhibit a mammillated appearance. The fibre-like cracks and the radial crystallization are both too fine to show in the Figure, which represents the specimen about natural size; but their position is indicated by the black triangles. The centre is a woolly-looking oval mass, three-quarters of an inch in its longest diameter, of a pale-grey colour, and may owe its appearance to its being semitranslucent and crystalline.

We have neither granular nor oolitic material visible in the Indian specimen. Cracks run through it in several directions; but these

are filled up with white crystalline infiltrations. One of these fissures, passing right through the central portion, gives off there a small quantity of a brown fluffy material, perhaps ferruginous.

No organic tissue seems to be traceable; and with this view it is interesting to find an inorganic so closely resembling an organic structure. It might well pass for *Cryptozoon* were the figure only of that form known to us, without its detailed description.

The specimen has now been deposited in the British Museum (Natural History), where a section has been cut from the face of the mass, so as to permit of a more exact examination of its structure.

The following is an extract from a letter to the Editor received from Prof. H. A. Nicholson, D.Sc., F.G.S., and gives the expression of his opinion after an examination of the Kulu limestone:—

"I have made a careful examination of the slide of the 'Kulu' specimen which you sent me, so far as its condition allows. I am not prepared to give any *positive* opinion about it, but have no hesitation in saying that, so far as I can judge, it is certainly *organic*; but that the organism (whatever may have been its nature) has been subjected, subsequently to entombment, to great alteration by pressure and crystallization. I have seen and examined very similar specimens, from both Silurian and Devonian strata, where one had unquestionably to deal with an organism, but where precisely similar alterations had taken place. Thus, masses of *Heliolites Grayæ* and *Heliolites porosa* often occur in this condition. Stromatoporoids also very often. Some of the things which M. Dupont has described from the altered Devonian Limestones of Belgium under the name of *Stromatactis* are of a *very* similar character. I have examined specimens of these, and while some appear to be due to a peculiar crystalline structure produced by inorganic causes, others seem to be certainly organic, and to be due to the action of pressure and crystallization, upon such organisms as *Heliolites porosa* and some of the Stromatoporoids. So far as your 'Kulu' specimen goes, I should not like to be dogmatic either way, but it is (to say the very least) *quite* as likely to be an altered fossil as a mere concretion. It shows, in fact, some features which would strongly incline me to the view that it is the former.—Aberdeen University, Feb. 20th, 1888."

IV.—On a Hornblende-Hypersthene-Peridotite from Losilwa, a low hill in Taveta District, at the S. Foot of Kilima-njaro, E. Africa.

By Frederick H. Hatch, Ph.D., F.G.S., H.M. Geological Survey.

A SMALL series of rock-specimens, consisting chiefly of fragments of basalt, dolerite, volcanic conglomerate and tuff, which were collected near Kilima-njaro, by F. Holmwood, Esq., C.B., late Consul-General at Zanzibar, was recently forwarded to the Museum at Jermyn Street, and placed by Dr. A. Geikie in my hands for determination. Among these specimens was a small block, the crystalline texture and high density of which at once arrested attention

Freshly fractured surfaces of this rock present numerous glistening facets, which with the aid of the pocket-lens are seen to be the cleavage-faces of a yellowish-green, a dark-green, and a garnet-red mineral. These minerals are respectively olivine, hornblende, and hypersthene in nearly equal proportions, the hornblende being perhaps slightly predominant. They form a holocrystalline granular aggregate, in which the grains are of nearly equal size and without crystalline contours; in other words, the structure is *allotriomorphic-granular.* Subordinate both in size and quantity to the three principal constituents is magnetic iron-ore.

A rude foliation or banding, which is only just perceptible in the hand-specimen, is rendered apparent under the microscope by a tendency to uniform orientation of the constituents, more especially of the hornblende-grains. This seems to indicate that the rock, like many other peridotites, constitutes, *in situ*, an integral part of a banded crystalline series—an assumption which by no means excludes the possibility of igneous origin.[1]

Under the microscope a brilliant picture is produced by the contrast between the bright grass-green of the hornblende and the beautiful salmon colour of the hypersthene, the olivine-grains being colourless. On rotating the section in polarized light (without the upper Nicol) the striking pleochroism of the hypersthene becomes visible. In order to determine the colour of the rays vibrating parallel to the different axes of elasticity, sections were sought in which the cleavage-lines intersected at an angle of about 90°. Such sections present, in convergent polarized light, the emergence of an axis of least elasticity (γ). In parallel light the colours of the rays vibrating parallel to a and β can be determined. They are:—

a=*rich salmon-red.*

β=*very pale yellow* (almost colourless).

Sections which have only one set of cleavage-lines extinguish straight, and give for rays vibrating in this direction (γ) the characteristic *pale sea-green* colour.

Thus we have $a > \gamma > \beta$.

The hornblende, which is of a rich green colour, is chiefly remarkable for the imperfection of its cleavage-cracks, these being not nearly so sharply defined as is usual in this mineral. Its relation both to the olivine and to the hypersthene shows that the hornblende was the last product of consolidation. It is found, for instance, enclosing grains of both hypersthene and olivine—a structure which, when more largely developed, produces the 'lustre-mottling' described by Williams and others. The pleochroism, which is marked, is as follows:—

a=*pale yellow.*

β=*yellowish green.*

γ=*bluish green.*

$\gamma > \beta > a$.

[1] Thomson ("Through Massai-Land," London, 1885) repeatedly mentions the occurrence of metamorphic rocks in this neighbourhood. They are seen, according to

The olivine is perfectly fresh and consequently colourless. High magnification discloses, both in this mineral and in the hornblende, the presence of parallel rows of opaque rod-like enclosures. The freshness of the minerals that contain them seems to preclude the idea of these bodies being of secondary origin.

The iron-ore occurs in irregular opaque grains which are easily attracted, and removed from the powdered rock, by a small bar-magnet. These grains are often edged by irregular plates of a translucent green mineral, which also occurs in isolated grains, or included in the hypersthene. In the latter case it sometimes assumes an octahedral form. It is isotropic and belongs probably to the spinell-group (pleonast or hercynite).

With regard to the name applied to this rock, its right to a place among the peridotites is at once established by its high density (sp. g.=3·3), the complete absence of a felspathic constituent, and the presence of a considerable proportion of olivine; although the latter is not the dominant constituent. Were the classification advocated in the new edition of Rosenbusch's "Physiographie der massigen Gesteine"[1] to be followed, the rock would have to be referred to the hornblende-picrites. Since, however, it bears no resemblance in structure and composition either to the rocks to which Tschermak originally gave the name picrite, or to those, for which 15 years later Prof. Bonney proposed the name hornblende-picrite, I do not feel justified in adopting these terms. Indeed no small confusion seems to have been caused, here as in other cases of rock-nomenclature, by the modification in the meaning of a term, the extension of which has been clearly limited by its originator.

The name picrite was given by Tschermak,[2] in 1866, to crystalline rocks which are intrusive in the limestones and sandstones of the Cretaceous and Eocene formations of the highlands between Neutitschein, Teschen, and Bielitz, in Moravia and Silesia. These rocks are described as consisting "to the extent of one half of crystals and grains of olivine; further of a lime-felspar, together with diallage, which can be replaced by hornblende, augite or biotite. The texture is porphyritic, with regard to the olivine, or finely granular." . . . . "Picrite bears the same relation to olivine-gabbro as basalt or melaphyre to gabbro."[3] Like basalt it often possesses "an interstitial substance which consists partly of microlites, partly of a structureless isotropic glass."[4]

Later on we find Gümbel[5] applying the term *palæopicrite* to altered rocks which consisted originally of olivine, pyroxene, and a small

this author, to crop out at the very foot of Kilima-njaro on the E. and S. sides. O. Mügge (Neues Jahrb. B.B. iv. 1886, p. 576) has described gneissose mica-schists and amphibolites from the southern portion of Massai-Land, as constituting members of a "gneiss or granite-gabbro formation."

[1] 1887, p. 260.

[2] Sitzungsber. K. K. Akad. der Wissensch. Wien, 1866, Bd. liii. p. 260.

[3] Sitzungsber. K. K. Akad. der Wissensch. Wien, 1867, Bd. lvi. p. 274.

[4] Die Porphyrgesteine Oesterreichs, etc. Wien, 1869, p. 245.

[5] Geogn. Beschreib. des Fichtelgebirges, Gotha, 1879, p. 150.

quantity of plagioclase and brown mica. The new word was scarcely wanted; but still an intelligible use can be made of it, if it be noted that the palæopicrites bear the same relation to the diabases that the picrites do to the basalts. In short the palæopicrites are olivine-diabases in which the felspar is quite subordinate. In this country we have as examples of typical palæopicrites, the Blackburn and Inchcolm rocks, described by Dr. A. Geikie.[1]

In 1881 Prof. Bonney[2] proposed the subdivision of the picrites into hornblende-picrite and augite-picrite, according as the dominant bisilicate is hornblende or augite. Adopting this subdivision, Rosenbusch, in his new edition, has defined the hornblende-picrites as peridotites which consist essentially of olivine and hornblende, and the picrites as peridotites which consist essentially of olivine and augite, the term peridotite being restricted to "plutonic rocks (*Tiefengesteine*) with hypidiomorphic-granular structure and characterized by the absence of felspar and the presence of abundant olivine." This, it will be seen, is a considerable change in the meaning originally attached by Tschermak to the term picrite; and the latter, as defined by Rosenbusch, admits of considerable variation in structure and affinities. On the other hand, Tschermak's picrites (*e.g.* that from Gümbelberg near Neutitschein) have been relegated to a new group, viz. that of the "picrite-porphyrites."[3]

The conclusion to be drawn from these digressive considerations is that the picrites (or palæopicrites) are olivine-augite rocks which possess affinities with, and pass, by an increase in the amount of felspar, into dolerites (or diabases) and basalts; while the hornblende-picrites, on the other hand, appear to be rocks which possess affinities with, and pass into, diorites.

The peridotite from Kilima-njaro, described above, contains no trace of felspar, has a specific gravity of 3·3, is holocrystalline and granular, and exhibits indications of foliation—characters which are incompatible with those of the picrite group. It bears, however, some resemblance to the hornblende-peridotites of Peekskill, Hudson River, N.J., described by G. H. Williams;[4] and I have therefore followed his system of nomenclature. If a distinctive name were really requisite, the name Cortlandtite, suggested by Williams for these rocks because of their relation to the Cortlandt series of Dana, might be adopted.

Mr. Teall has shown me peridotites from Scourie in Sutherlandshire, which bear a still more striking likeness to the Kilima-njaro rock.[5]

[1] Trans. Roy. Soc. Edin. vol. xxix. (1880), p. 504.
[2] Q. J. G. S. vol. xxxvii. (1881), p. 137.
[3] Physiog. der Massig. Gest. 1887, p. 518.
[4] Amer. Journ. of Sci. vol. xxxi. 1886, p. 26.
[5] These Scourie rocks are placed by Rosenbusch among the hornblende-picrites, *l.c.* p. 267.

V.—On the Humerus of *Euclastes*.

By Louis Dollo, C.E.;
Assistant Naturalist in the Royal Museum of Natural History of Belgium, Brussels.

I.—To avoid useless repetitions, I shall consider as admitted what I have said in my paper "*Sur le genre Euclastes*,"[1] especially:

1. *Euclastes*, Cope = *Chelone*, Owen (non Ritg.) (pars) = *Lytoloma*, Cope = *Puppigerus*, Cope (pars) = *Glossochelys*, Seeley = *Pachyrhynchus*, Dollo = *Erquelinnesia*, Dollo.

2. The diagnosis of the *Propleuridæ*, as I have completed it.

II.—This being stated, I think that the far more chelydroid than chelonoid humerus of the above-named Turtles is one of the most interesting facts of their organization. Indeed, if we remove, for the present, from the Dactyloplastrine Cryptodiran Thecophorian Chelonians:[2]

1. The *Trionychidæ*, with which the *Propleuridæ* have nothing in common, as is sufficiently proved particularly by their carapace and their plastron;

2. The *Propleuridæ* themselves, since it is precisely these which we are comparing with the others; we have only really to examine the two following types:

1. The *Chelonidæ*;

2. The *Chelydridæ*.

Now, by their skull[3] and their procœlous caudal vertebræ,[4] the *Propleuridæ* are related to the first-named family. Their carapace and their plastron would, it is true, appear to place them nearly at an equal distance between the *Chelonidæ* and the *Chelydridæ*, especially on account of the degree of ossification. Nevertheless, as the nuchal bone does not possess the characteristic costiform process of the latter,[5] I think that we should not be justified in regarding the structure of the carapace and plastron as a sign of relationship with the last-mentioned family; it is a question, in the case which we are considering, of a simple coincidence in two parallel series. The *Propleuridæ* might then be looked upon as aberrant *Chelonidæ*, ranking

[1] L. Dollo, "Sur le genre *Euclastes*," Société géologique du Nord, Annales xv. 1887-88 (*in the press*).

[2] L. Dollo, "Première Note sur les Chéloniens du Bruxellien (Eocène moyen) de la Belgique," Bull. Mus. Roy. Hist. Nat. Belg., t. iv. 1886, p. 84.

[3] R. Owen and T. Bell, "Monograph on the Fossil Reptilia of the London Clay," part i. *Chelonia*, Palæontographical Society, 1849, pp. 9 and 10; E. D. Cope, "Synopsis of the Extinct Batrachia, Reptilia and Aves of North America," Trans. Amer. Phil. Soc. Philadelphia, 1871, vol. xiv. p. 148; L. Rütimeyer, "Ueber den Bau von Schale und Schadel bei lebenden und fossilen Schildkröten als Beitrag zu einer paläontologischen Geschichte dieser Thiergruppe," Verhandl. d. naturforsch. Gesellschaft in Basel, vol. vi. 1874-78, p. 122.

[4] L. Dollo, "*Euclastes*," etc. (*loc. cit.*). It is known that, in the *Chelydridæ*, the caudal vertebræ are opisthocœlous (E. D. Cope, "The Vertebrata of the Tertiary Formations of the West," Rep. U.S. Geol. Surv. Territ. (F. V. Hayden), 1884, p. 111).

[5] G. Baur, "Osteologische Notizen über Reptilien," Zoologischer Anzeiger, 22 Novembre, 1886, p. 688; R. Lydekker and G. A. Boulenger, "Notes on Chelonia from the Purbeck, Wealden, and London Clay," Geological Magazine, June, 1887, p. 273; L. Dollo, "Première Note sur les Chéloniens oligocènes et néogènes de la Belgique," Bull. Mus. Roy. Hist. Nat. Belg. t. v. 1888, p. 92.

as a subfamily, my *Pachyrhynchynæ*,[1] did not their peculiar humerus show us a type having limbs wholly different from those of the *Chelonidæ*, and even to such a degree that, on account of them, it is necessary to create a distinct family, the *Propleuridæ* of Mr. E. D. Cope.[2]

III.—We will now proceed, more in detail, to the study of the humerus in question:

1. To show, first, that it is really more chelydroid than chelonoid;

2. Then, as it might be doubted, we shall demonstrate that it really belongs to the Turtle to which we ascribe it;

3. Lastly, we shall draw from our observations the conclusions to which we shall be led, notably with regard to Phylogeny.

IV.—To begin with, we shall compare the humerus of *Chelydra* to that of *Chelone*; we shall find:[3]

CHARACTERS.	CHELYDRA (Fig. 1).	CHELONE (Fig. 3).
1. General form.	Elongated, sigmoid. Section, at the narrowest point, distally to processes, elliptic, but differing slightly from a circle.	Less elongated, rectilinear. Section, at the narrowest point, distally to the process, more or less elliptic, but very flattened.
2. Head. (*g.*)	Longest axis very oblique on the longest axis of the distal end.	Longest axis perpendicular to the longest axis of the distal end.
3. Mesial process. (*i.*)	Hardly rising above the head, *when the longest axis of the humerus is vertical.*	Rising very much above the head, when the longest axis of the humerus is vertical.
4. Lateral process. (*k.*)	Placed close to the head.	Clearly detached from the head and placed nearer to the distal end.
5. Intertubercular fossa.	Placed close to the head, with the longest axis perpendicular to the longitudinal axis of the humerus, and wedged in between the lateral and mesial processes.	Less well circumscribed, oblique, with the greatest axis nearly directed according to the longitudinal axis of the humerus, extending towards the distal end.
6. Condyles. (*a, b.*)	Well marked, and forming nearly the whole of the distal end of the humerus.	Forming hardly half the distal end of the humerus; displaced mesially.
7. Ectepicondyle. (*d.*)	Hardly developed.	Much more developed; it causes the condyles to be displaced mesially.
8. Ectepicondylar foramen. (*e.*)	Missing; replaced by a groove.	Present, but placed nearer to the longitudinal axis of the humerus than the groove of *Chelydra*.

V.—But:

1. By its general form;
2. By its head;
3. By its mesial process;
4. By its lateral process;

} (Fig. 2.)

5. By its intertubercular fossa;

[1] L. Dollo, "Première Note sur les Chéloniens landéniens (Eocène inférieur) de la Belgique," Bull. Mus. Roy. Hist. Nat. Belg. t. iv. 1886, p. 139.
[2] E. D. Cope, "Synopsis," etc., p. 235.
[3] L. Dollo, "Chéloniens oligocènes," etc., p. 78.

the humerus of *Euclastes* is of the type of that of *Chelydra* and not of that of *Chelone*.

VI.—Nevertheless, we shall remark that, although being more chelydroid than chelonoid as a whole, the humerus of *Euclastes*;

1. By its curvature less sigmoid and its flatter form;

2. By its head slightly less oblique on the greatest axis of the distal end;

3. By its lateral process less elevated, slightly more detached from the head, and less distinctly perpendicular to the surface on which the orifice of the ectepicondylar foramen is situated;

4. By its condyles less developed and slightly more displaced mesially;

5. By its more marked ectepicondyle;

6. By the presence of an ectepicondylar foramen;

differs slightly from the type of *Chelydra* and shows an approximation towards *Chelone*.

The foregoing considerations prove, evidently, that, if the limbs of *Euclastes* were infinitely less adapted to aquatic life than those of *Chelone*, they were, however, more so than those of *Chelydra* and perhaps even than those of *Trionyx*.[1] But we shall return to this subject further on.

VII.—Does the humerus referred to *Euclastes Gosseleti*, Dollo, belong really to that Turtle? I think so; because:

1. The fossil Vertebrates of the Erquelinnes sandpits were sent to the Museum of Brussels in separate parcels containing bones imbedded in sand. Each parcel included the remains of one specimen. Now, we have got two humeri appertaining to the same side (therefore from distinct individuals), and each of them came in its own parcel containing exclusively bones of *Euclastes*; I shall also add that they were sent at different times;

2. The humeri agree in size with the accompanying skeletons;

3. They are also in the same state of fossilization, they have the same aspect;

4. If they should not be admitted to belong to *Euclastes*, taking into consideration the Chelonian fauna of Erquelinnes, there would only remain to look upon them as *Trionyx*; but:

A. They are of too large a size to have appertained to the skeletons of *Trionyx* of which carapaces have as yet been found at Erquelinnes;

B. They are also too dark in colour;

C. They offer besides differences from *Trionyx* in the general form, the head, the lateral process, the intertubercular fossa, the condyles, the ectepicondyle, and the presence of an ectepicondylar foramen;

5. Moreover, *Euclastes* is so abundant at Erquelinnes comparatively with other Chelonians (certainly 10 to 1 with respect to *Trionyx*) that:

A. If the humeri had been found isolated, which is not the case;

[1] On account of the distal extremity of the humerus, and the metapodials (or phalanges) which seem devoid of condyles, as has already been observed by Mr. E. D. Cope (Tertiary Vertebrata, etc., p. 111), and as I have also noticed (L. Dollo, *Euclastes*, etc., *loc. cit.*).

B. If their size corresponded equally with that both of *Trionyx* and of *Euclastes*, which is not the case;

C. If the fossilization, and especially the colour, had been the same, which they are not;

they ought still, according to the law of probability, to be referred to *Euclastes*;

6. Lastly, on the other side of the Atlantic, Mr. E. D. Cope has made known, a long time ago,[1] that the Cretaceous *Propleuridæ* had a more chelydroid than chelonoid humerus, and he was so much impressed by this structure, amongst others, that he began by placing with the *Chelydridæ* the genera which have since composed his *Propleuridæ*.

After what has been said above, it seems to me beyond doubt that the humeri described as belonging to *Euclastes* really appertain to that genus.

However, a further verification, which I am going to mention, appears to me possible. The Erquelinnes Chelonians are imbedded in sand, consequently in a matrix devoid of cohesion; on the contrary, the London Clay Chelonians, several of which ought certainly to be classed among the *Propleuridæ*,[2] are found not only in clay, a more coherent substance, but each of them is said to be included in a "nodule of petrified clay."[3] Under these conditions, the latter show with more certitude the bones which come from the same individual. Now, *Chelone longiceps*,[4] Owen, is one of the types belonging to the *Propleuridæ*, as I understand them, and the skull, the carapace, as also the humerus, are still adhering together.[5] If, then, the humerus is of the shape of our Fig. 2 (*Euclastes Gosseleti*, Dollo), the above-mentioned verification will be made. Therefore, it is to be wished that an English naturalist should consent to examine this point; and it is precisely to make known this desideratum that I have chosen the pages of the Geological Magazine to publish the present paper. I am aware that Sir R. Owen says, speaking of the humerus in question: "The humerus presents the usual characters of that of the *Chelones*."[6] But the celebrated naturalist may not have had his attention especially drawn to this bone; moreover, judging by the figure which he gives of it,[7] it appears to me somewhat mutilated, as also imperfectly cleared of its matrix. I shall add that it is not one specimen only that should be studied, but all those coming from the London Clay, which can be referred to *Propleuridæ*, and in which the humerus is associated, beyond a doubt, with other characteristic remains.

VIII.—It ought to be inferred from the preceding pages that the *Propleuridæ* were Turtles not so well adapted to an aquatic life as

[1] E. D. Cope, "Synopsis," etc., pp. 130 et 235.

[2] L. Dollo, "Chéloniens landéniens," etc., p. 137; R. Lydekker and G. A. Boulenger, "Notes on Chelonia," etc , Geol. Mag. p. 271.

[3] R. Owen and T. Bell, "Monograph," etc., p. 40.

[4] R. Owen and T. Bell, "Monograph," etc., p. 16.

[5] R. Owen and T. Bell, "Monograph," etc., pl. iv.

[6] R. Owen and T. Bell, "Monograph," etc., p. 17.

[7] R. Owen and T. Bell, "Monograph," etc., pl. iv.

true *Chelone*. Since the first Chelonians were certainly terrestrial,[1] and that the *Propleuridæ* are, especially as far as the limbs are concerned, nearer to the primitive stock of the *Testudinata* than the living *Chelone*, it may be inquired whether these *Propleuridæ* are not the direct ancestors of the latter. I do not think so, for the following reasons. Notwithstanding that the Cretaceous beds[2] containing *Propleuridæ* are, without doubt, older than the Cretaceous beds[3] in which the oldest true *Chelone*[4] has been found, and that, consequently, in the present state of knowledge, there is no contradiction so far, as to time, I am of opinion that the structure of the mandible[5] suffices alone to make us consider that descent as impossible. Indeed, a short symphysis is primitive, a long one derived. Therefore, it is not at all likely that the latter has given rise to the former. Moreover, the carapace, the plastron, and the choanes[6] point also in the same direction.[7]

IX.—But, without being the direct ancestors of the *Chelonidæ*, the *Propleuridæ* may enlighten us as to these ancestors, just as *Hesperornis*,[8] which, on account of its much reduced wings, could not be the precursor of any of the living Birds, throws light on the dentition of the forms from which they have been derived. The *Propleuridæ* show us the large head,[9] the separated nasals,[10] and the more terrestrial limbs possessed at one time by true *Chelone*. Thus, Palæontology furnishes material proof of facts already foreseen by Morphology.

X.—According to Mr. E. D. Cope,[11] the relations between the Dactyloplastrine Cryptodiran Thecophorian Chelonians are the following:

Chelydridæ.
|
Propleuridæ.
|
Chelonidæ. *Trionychidæ.*
| |

I cannot admit this grouping, because:

1. How could the *Trionychidæ* have transmitted to the *Propleuridæ* the marginal bones, which they have lost themselves?

[1] G. Baur, "Notizen," etc, p. 688.

[2] L. Dollo, "*Euclastes*," etc. Because, in England, there is no Danian (A. Geikie, "Text-Book of Geology," p. 815); and, in the United States of America, the fossils found in the *Euclastes*-beds, for instance, *Teredo tibialis* and *Gryphæa vomer*, are considered by D'Orbigny as Senonians (Prodrome de Paléontologie stratigraphique, Paris, 1850–52).

[3] Danian (Tuffeau de Maestricht).

[4] "*Chelone Hoffmanni*," Gray. . . . "Bis jetzt ist dies indessen das alteste Fossil aus Europa, das mit vollem Recht den Namen *Chelone* tragt" (L. Rütimeyer, "Ueber den Bau," etc., p. 119).

[5] L. Dollo, "Chéloniens landéniens," etc., p. 134.

[6] L. Dollo, "Chéloniens landéniens," etc., p. 133.

[7] L. Dollo, "*Euclastes*," etc. (*loc. cit.*).

[8] O. C. Marsh, "Odontornithes; a Monograph on the Extinct Toothed Birds of North America," New Haven, 1880, p. 62.

[9] L. Rütimeyer, "Ueber den Bau," etc., p. 122.

[10] L. Dollo, "Chéloniens landéniens," etc., p. 132.

[11] E. D. Cope, "Tertiary Vertebrata," etc., p. 115.

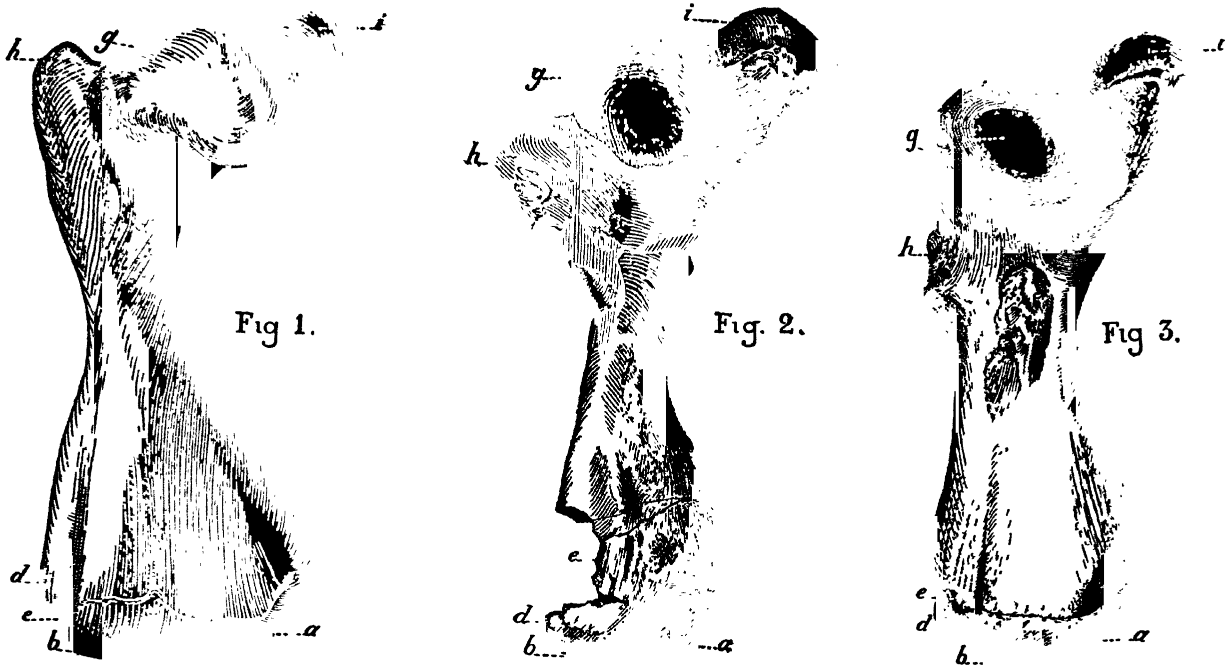


FIG. 1.—Humerus of *Chelydra*. FIG. 2.—Humerus of *Euclastes Gosseleti*, Dollo [Lower Landenian (Lower Eocene, *pars*) of Erquelinnes].
FIG. 3.—Humerus of *Chelone*. *a*, entocondyle; *b*, ectocondyle, *d*, ectepicondyle, *e*, ectepicondylar foramen, or ectepicondylar groove; *g*, head of the humerus; *h*, lateral process; *i*, mesial process.

2. How have the procœlous caudal vertebræ of the *Propleuridæ* become the opisthocœlous caudal vertebræ of the *Chelydridæ?* Could they have turned themselves the other way? How could the nuchal rib, lost by the *Propleuridæ*,[1] be present in their descendants, the *Chelydridæ?*

3. Whichever might have been the origin of the *Chelonidæ*,[2] their relations with the *Propleuridæ* do not seem to allow of a diphyletic phylogenetic tree for these two families.

XI.—Therefore, we should more likely have:

```
                         Chelonidæ.
                             |       Propleuridæ.
                             |            |
                             |____________|
Trionychidæ.                       |                  Chelydridæ.
     |                             |                       |
     \_____________________________v_______________________/
DACTYLOPLASTRINE CRYPTODIRAN THECOPHORIAN CHELONIANS.
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XII.—One more word before concluding. The *Propleuridæ* not being true Turtles, were they pelagic in their habits? The marine nature[3] of the deposit proves nothing in this case, the beds in question containing also *Trionyx*, which, as is well known, lives in rivers.

The humerus of the *Propleuridæ* has already shown us that the limbs of these Chelonians were less well adapted to aquatic life than those of the true Turtles, but that they were more so than those of *Chelydra*, or even than those of *Trionyx*. The metapodials point also in the same direction. As is equally demonstrated by the carapace and diet,[4] *Euclastes* was, therefore, probably a very littoral marine type.

VI.—WOODWARDIAN MUSEUM NOTES: ON SOME ANGLESEY DYKES. No. III.

By ALFRED HARKER, M.A., F.G.S.,
Fellow of St. John's College, Cambridge.

IN the first paper of this series[5] were described several dykes from the shores of the Menai Straits, belonging apparently to one system of intrusions, and some of them cutting Carboniferous strata. Their precise age, however, can be fixed only on the supposition that they may fairly be correlated with certain post-Carboniferous but pre-Permian dykes in the Anglesey Coal-field. These latter rocks have a strong general resemblance to the Menai Straits dykes, and as they are by no means easily accessible, they will not be described in detail. Only one will be selected, as offering a

[1] L. Dollo, "*Euclastes*," etc. (*loc. cit.*).

[2] "On the Relations between *Athecæ* and *Thecophora*," see L. Dollo, "Chéloniens oligocènes," etc., p. 83.

[3] A. Rutot, "Sur la position stratigraphique des restes de Mammifères recueillis dans les couches de l'Eocène de Belgique," Bull. Acad. Roy. Belg. 1881, t. i. p. 22.

[4] L. Dollo, "Chéloniens landéniens," etc., p. 138.

[5] GEOL. MAG. Dec. III. Vol. IV. p. 409, 1887. See also *op. cit.* p. 546.

rather pronounced type: the specimen is from the Henslow collection.

[571.] Dolerite from dyke in coal-pit at Llanfihangel. This rock is very fresh and of rather coarse grain: it shows at a glance a tendency to parallelism in the felspars. Magnetite is abundant in the slide, partly in square sections earlier than any other constituent, partly in granular and imperfectly crystalline patches later than the dominant felspar, but included in the augite.

The felspars divide into two distinct generations. The earlier ones occur in well-formed crystals, of elongated rectangular section up to 0·1 inch in length, with a fine distinct twin-lamellation. These lamellæ, sometimes interrupted or discontinuous, correspond to the albite law, but they are often crossed by pericline twinning, and some of the larger crystals exhibit the Carlsbad type also. These earlier felspars have little or no zoning, and seem to be andesine or labradorite. They are, however, not strictly all of one stage, for we may see one crystal moulding another, which in turn encloses a small felspar of still earlier consolidation.

The later generation of felspars differs considerably from the former. The crystals are less elongated and usually shapeless. They are less finely twinned, and the lamellation is rendered indistinct by the strong zonary banding which is made manifest between crossed Nicols. In all these Anglesey dolerites this growth in concentric zones of different optical characters is highly characteristic of the later felspars. It points to a rather rapid change in the chemical constitution of the magma during the closing stages of consolidation, and perhaps depends partly on the almost simultaneous separation of the augite.

In the present rock the augite is not very abundant, and does not build ophitic plates of any great extent. It rarely presents imperfect crystal boundaries to the later felspars, and is on the whole nearly contemporaneous with them. The mineral is pale brown, with the usual prismatic cleavage.

It will be observed that the Llanfihangel rock compares closely with those from the Straits, such, for example, as the Cadnant dyke [545].

Before proceeding further, it may be noticed that there are other dykes in southern Anglesey, which are probably not to be grouped with the foregoing. They differ from them both mineralogically and structurally, and approach more nearly to the characters of parts of the Holyhead dykes to be described below. As an example, a dyke at Bodowen, on the west side of the Malldraeth estuary, is chosen.

[598.] Olivine-diabase of Bodowen. This is an ophitic rock with but one set of felspars. Under a low objective we see first skeletons of ilmenite, clouded with semi-opaque leucoxene, and some crystals of magnetite. There are also numerous rounded light-green patches, in part serpentine, in which are imbedded granules of unaltered olivine. These patches, often included in the augite, are crowded with minute matted fibres, perhaps chrysotile, but more probably

tremolite. Felspar crystals are plentiful, mostly once twinned and with moderately wide extinction-angles in sections perpendicular to the twin-plane. They are moulded and enclosed by large ophitic plates of augite with the characters usually found in that mineral in the Welsh diabases. The edges of these plates are touched here and there with brown hornblende, with the regular crystallographic relations to the augite, and possibly derived from it. Where serpentinous pseudomorphs are included in the augite, there is often a fringe of pale green or colourless amphibole, with a definite crystal orientation projecting into the serpentinous mass. This mineral is no doubt a "secondary enlargement"[1] of the augite crystal from which it grows, though its substance must be derived from the destruction of the olivine.

Holyhead main dyke.—We now pass on to the island of Holyhead, where two large dykes were first noted and described by Henslow. The main one, with an average width of 60 feet, traverses almost the whole length of the island, running in a slightly curved line, but with an average bearing north-west and south-east, from near the South Stack to Cymmeran Bay. It cuts the quartz-rock, the green schists, and the serpentine, occasionally throwing off veins or branches. Henslow carefully notices the contact-alteration of the adjacent rocks, and makes the observation that "where the dyke is contained between parallel walls of the schist, and appears as though it were filling up some large crevice, the effects are never so striking as in those places where it ramifies and becomes intimately associated with the surrounding mass."[2] He also remarks the variability of character displayed in this and the following dyke when traced along their length, a feature still more clearly brought out by an examination of slices under the microscope.

[605.] Olivine-diabase from Porth-dafarch (Port Dafreth of Henslow). The name diabase is employed for this rock, despite a certain approach to the doleritic type, shown by a tendency to develope a second generation of felspars: the structure is ophitic. Olivine grains are abundant and tolerably fresh: they are sometimes slightly penetrated by the felspars. A few imperfect crystals of magnetite are included by the olivine, but the bulk of the mineral is posterior to the dominant felspar. The felspar, apparently labradorite, shows cross-twinning and some zonary shading in polarised light. A few rather shapeless crystals, with strong zoning and less pronounced twin-lamellation, belong to a rather later stage. Pale-brown augite forms large ophitic plates including olivine and felspars alike. The plates are divided by definite lines into distinct fields, with crystalline continuity, but slightly different optical properties, and this structure sometimes approaches the regularity of the well-known "hour-glass augite."

[614.] Dolerite from a small branch of the dyke at the same locality. This rock presents no special peculiarities: if olivine has been present, it is now lost in ill-defined secondary products. The

[1] *Cf.* Van Hise, Amer. Journ. Sci. (3) xxiii. p. 385, 1887.
[2] Trans. Camb. Phil. Soc. vol. i. p. 419, 1822.

structure is distinctly porphyritic as regards the felspars; there is a rather fine-grained ground of ophitic appearance.

[617.] Specimen from the southern part of the dyke, showing the junction of two different rocks. The coarser-grained one is seen under the microscope to be a diabase, partly ophitic, partly granulitic in structure: no evidence of olivine is to be detected.

The finer-grained rock has a ground-mass of minute felspar-microlites and crystals of magnetite, moulded by augite. In this ground are imbedded felspars of rectangular section and a few idiomorphic augites. This rock, which may be styled an augite-andesite, is doubtless a small dyke intruded into the diabase, for it shows a marked fluxional appearance along the line of junction.

Cordier compared specimens from this main dyke of Holyhead Island with the "granitoidal ophites of the Vosges."

Holyhead Eastern dyke.—The second large dyke in the island probably branches off at an acute angle from the main dyke about the middle of its length, and runs in a direction N.W. by N. past the east side of Holyhead Mountain, passing out to sea at the north end with a thickness of 80 feet. Our specimens are from the northern extremity, from Cae Seri on the road to South Stack, and from Bryniau Geirwen on the road to Porth-dafarch. They vary in grain and in general appearance to the eye, some resembling gabbro and others diabase and dolerite. Their intimate structure reveals corresponding variations, but it is perhaps best to class them all together as hornblende-diabases of various types.

Under the microscope all these rocks are seen to contain a rather unusual quantity of apatite in colourless acicular prisms. Magnetite occurs plentifully, in composite crystalline forms, in ragged grains and patches, and in crystal frameworks. These two minerals always have the priority in the order of consolidation.

The augite is of the very pale-brown variety, and when it exhibits crystal outlines, has the familiar octagonal cross-section. Besides the well-defined prismatic cleavage, there are traces of another, transverse to the length of the prism. The mineral is usually fresh; its chief secondary product seems to be serpentine. These characters, which are approached by the augite of many Welsh diabases, agree with the variety malacolite. Hornblende is plentiful in all but one slide [636]. It is the deep-brown 'basaltic' variety, with absorption-formula $\gamma > \beta >> a$. The mineral occurs sometimes in good prisms, truncated, except in the smallest crystals, by the clinopinacoid. Much of the hornblende, however, occurs in close association with the augite, the two minerals having, as usual, the vertical axis and orthodiagonal common. The hornblende mostly borders the augite, and when there are definite crystal outlines to such a border, they are those proper to the former mineral. This is, therefore, not a case of 'paramorphism,' but an intergrowth of the kind termed *ergänzende* or complementary hornblende. Patches of hornblende in the interior of the augite plates are probably also a parallel intergrowth. The hornblende crystals occasionally enclose grains of augite without any crystallographic

relation, and in all cases the hornblende in these rocks seems to be in the main posterior to the pyroxene. Greenish fibrous amphibole is common as a 'secondary enlargement' in crystalline continuity with the original hornblende, and it sometimes extends as a fringe along the margin of the augite. A similar relation is met with in some of the German hornblende-diabases, *e.g.* the 'proterobase' of Kürenz near Trier.

Striated felspar is always abundant in the rock of the dyke, and appears to belong mainly to the andesine-labradorite series. It is often strongly zoned, or if the felspars do not all belong to one stage, the later ones show this structure. In accordance with the usual rule, the outer zones always give lower extinction-angles than the inner part of the crystal.

The only other mineral to be mentioned is biotite, of which a few flakes are seen in one slide (Bryniau Geirwen). The specimens present then, it is evident, a community of general mineralogical constitution, and the diversity of structure noted below is therefore a matter of some interest.

[626.] From the northern termination of the dyke. In this rock the augite has idiomorphic boundaries, and is moulded by the felspar. The general aspect to the eye is not unlike some gabbros.

A specimen of Mr. Marr's from Cae Seri is a rather coarse-grained gabbro-like rock. The felspar and augite penetrate one another in a rather curious way, and must on the whole have consolidated simultaneously.

[635.] Bryniau Geirwen. This shows the same peculiar type of structure; the augite sometimes presents crystal outlines to the felspar, which moulds it, while in other places these relations are reversed, the felspar crystals penetrating the augite.

[636.] Bryniau Geirwen. This specimen, from the same locality as the last, is an ordinary ophitic diabase.

Finally, a rock procured by Professor Hughes from the same place is also ophitic in structure, but shows a decided tendency to the doleritic type. There are two generations of felspar; one in lath-shaped crystals penetrates the augite and hornblende; the other, more equidimensional and without regular outlines, is of later consolidation than those minerals.

The existence of such wide differences of structure in rocks forming part of one and the same igneous mass, offers a problem of which petrologists have not yet given a complete solution.

Henslow collected specimens from two dykes, the larger one having a width of eighteen feet, at Port Newry, near Holyhead town. As he remarked, the rock here much resembles "the harder portions of the dyke at Port Dafreth" [605]. The chief difference is the greater abundance of olivine.

[638.] Olivine-dolerite of Port Newry. The olivine, which often builds good crystals and has the pinacoidal cleavages well developed, is on the whole the first product of consolidation, though sometimes slightly penetrated, as at Porth-dafarch, by the earliest-formed felspars. The mineral is for the most part pseudomorphed by green

serpentine in the fashion figured by Tschermak[1] and others. The felspar of this rock seems by its extinction-angles to be near anorthite. The most numerous generation is in elongated crystals with fine lamellation. There are also later felspars in shapeless crystals with wide twin-lamellæ and strongly-marked zonary banding in polarised light. The magnetite is later than the dominant felspar and earlier than the augite; it sometimes shows rod-like aggregations of octahedra. The pale-brown augite, in plates with an ophitic tendency, has here again a marked hour-glass structure, although the dividing lines have often an irregular disposition, and even run parallel to the outlines of projecting felspar crystals. It may be remarked that the hour-glass augites of the Welsh rocks rarely exhibit the regularity of structure figured by Werveke, etc.[2]

Several rocks from Holyhead stand on the border-land between the diabases and dolerites, as those families are here defined. The present specimen seems best referred to the latter category, the *porphyrische structur* (Rosenbusch) being well marked: the absence of ilmenite and hornblende is also to be noted in this connection.

Other dykes in Holyhead Island are marked on the Survey Map and mentioned by Sir A. Ramsay. They all strike in a general N.W.—S.E. direction, "which is also that of the fault which crosses Holyhead Mountain between Gogarth and Porth-y-corwgl, and all coincide more or less with the run of many of the larger joints." We have seen that the dykes of the Menai Straits and the Coal-field have about the same bearing, but they show lithologically little resemblance with those last described; and as the rocks cut by the Holyhead dykes are themselves of dubious age, speculation on the date of the dykes must necessarily be reserved.

NOTICES OF MEMOIRS.

I.—A Comparative Study of the Till or Lower Boulder-clay in several of the Glaciated Countries of Europe—Britain, Scandinavia, Germany, Switzerland, and the Pyrenees. By Hugh Miller, F.R.S.E., F.G.S., Assoc.R.S.M.[3]

THE sections of foreign Till examined by the author occur chiefly in the neighbourhood of the Trondhjem Fjord in Norway, at Berlin and Leipzig in Germany, near the Lake of Geneva in Switzerland, and in the valleys of the Pyrenees directly south from Pau in Southern France. In these countries and in Britain the Till bears an identical character. It is not more variable throughout Europe than the author has found it to be in Scotland and Northern England. On the basement-gneiss at Christiansund in South-western Norway it is the same as on the basement-gneiss of Sutherlandshire; in the great limestone valley of Eaux Chauds in the Pyrenees it is scarcely

[1] Sitzungsb. d. k. Akad. d. Wien. vol. lvi. p. 283, and plate, 1867.
[2] Neues Jahrbuch, 1879, p. 823. Hussak, *Anleitung zum bestimmen der gesteinbildenden Mineralien*, p. 72; 1885.
[3] Read at the British Association, Manchester, 1887.

to be distinguished from the Till of the limestone valleys of Yorkshire. In all the places mentioned it bears the unmistakable character of a ground-moraine accreted under the direct weight of glacier-ice. The familiar features of the Till need not be recapitulated here, but the author insists that its essential character is that of a rude pavement of glaciated débris, ground from the rocks over which the glaciers have passed, with its larger boulders firmly glaciated *in situ* on their upper sides in the direction of ice-movement, and with a tendency to the production of fluxion structure here and there in the matrix, due to the onward drag of the superincumbent ice. In mere indiscriminateness of composition (which is the character often most emphasised) the Till is not to be distinguished from Boulder-clays formed under berg- or raft-ice, such as the highest marine clays of the Norwegian coasts, which are stuck promiscuously through with boulders derived from the glaciers of the interior. But the glaciation of boulders *in situ* the author finds to be a really crucial distinction; he readily detected this "*striated-pavement*" character in the Tills of all the districts above mentioned except Leipzig and Berlin, where the Boulder-clays resemble the Upper Boulder-clay (Hessle Clay) of the eastern seaboard of England and Scotland, and in the sections examined by him contained no blocks large enough to take the striæ.

REVIEWS.

I.—The Geological Survey of England and Wales.

Some time has elapsed since we last noticed a series of the Geological Survey Memoirs (Geol. Mag. for 1886, p. 65), and in the mean time a number of additional Memoirs have been published, attention having been drawn to only one of these (Geol. Mag. 1888. p. 31). Much more detail is inserted in these Explanations of the Survey Maps than was the custom in the earlier publications: but if on this account they afford somewhat heavier reading, they are also much more valuable for reference on questions both of scientific interest and of practical concern. Indeed the precise record of facts and a statement of the localities where particular information has been obtained, are always of great value to subsequent investigators, as well as to engineers and well-sinkers. We note also that the prices of these Memoirs are very moderate.

In addition to a number of General Memoirs on particular districts or rocks, no less than 66 Memoirs explanatory of the Survey Maps have now been published. Nevertheless much remains to be done ere the whole country is described in such detail. Portions of Hampshire and Dorsetshire have not yet been 'explained' in Survey publications; the Isle of Man and the Channel Islands have not at present been officially surveyed; while Cornwall and much of Devonshire, the South Wales Coal-field and the Old Red Sandstone area of Brecknock- Hereford- and Monmouth-shires offer tempting fields for future detailed surveys. Moreover, the Drift-deposits over

considerable portions of the Midland Counties, not to mention other areas, have not at present been mapped.

Our present object, however, is to notice the recent Memoirs, and these will be taken as far as possible in the order of publication.

1. "The Geology of the Country between and south of Bury St. Edmunds and Newmarket." By F. J. Bennett and J. H. Blake; edited with additions by W. Whitaker, F.R.S. 8vo. pp. 27. (London, 1886.) Price 1*s*.

This Memoir contains notices of the Chalk, Glacial Drift, River Gravels, etc. Interesting sections are given, showing the structure of the Glacial deposits and their relation to overlying "Post-Glacial" loam, which has yielded Palæolithic Implements. Numerous well-sections form an Appendix to the work.

2. "The Geology of the Country around Aldborough, Framlingham, Orford, and Woodbridge." By W. H. Dalton, edited (with some additions) by W. Whitaker, F.R.S. 8vo. pp. 59. (London, 1886.) Price 1*s*.

The district described in this Memoir is one of great interest to students of Pliocene geology, including as it does some of the famous Crag-sections near Orford and Aldborough. Mr. Whitaker contributes notes on the fossils and on the literature of the Coralline Crag, but the details given on this formation are confined to two pages, and there is no list of fossils. The accounts of the Red Crag and of the Chillesford Clay are fuller so far as stratigraphical details are concerned, but we miss an account of the fossils. The Palæontology will doubtless be treated in a general Monograph of the Pliocene formation, which we are informed is in preparation.

Short notices of the Chalk, Reading Beds and London Clay, and a more lengthy account of the Glacial Drift, are given, together with notes on the River Gravels, Alluvium, Shingle, and Blown Sand. The well-sections in the area are duly recorded.

3. "The Geology of the Country around Northallerton and Thirsk." By C. Fox Strangways, A. G. Cameron, and G. Barrow. 8vo. pp. 75. (London, 1886.) Price 1*s*. 6*d*.

The rocks described in this area include Millstone Grit, Magnesian Limestone (Permian), Keuper Sandstone and Marl, Rhætic Beds, Lias, Oolites (up to the Kimeridge Clay), Glacial and Recent deposits. The country embraces portions of the Cleveland, Hambleton, and Howardian Hills. The Memoir will be of particular interest to students of Jurassic Geology. Among the strata, the Ironstone series of the Middle Lias is of special economic importance, and detailed sections are inserted to show its mode of occurrence. Lists of fossils are given from the different formations. There is also an Appendix of well-sections, and a list of the more important works referring to the district.

4. "The Geology of the Country around Otterburn and Elsdon." By Hugh Miller. With Notes by C. T. Clough. 8vo. pp. 147. (London, 1887.) Price 2*s*. 6*d*.

This is the first Memoir of the Geological Survey devoted to the Carboniferous Rocks of the English Border, and a full description

has been given of them. Some older rocks are exposed in the area, the Wenlock Beds and Lower Old Red Sandstone (associated with the Cheviot porphyrite), but they occupy small areas, and require but brief notice.

The Carboniferous rocks are grouped as follows:—

Carboniferous Limestone Series.	*Upper Series.*	Calcareous Division.	
	Lower Series.	Carbonaceous Division	(Scremerston Beds).
		Tuedian Division, or Tweed Beds.	Fell Sandstones.
			Cement-stone Beds & Rothbury Limestones.
			Lower Freestones.
			Basement Beds.

The Basement Beds are probably on the horizon of strata elsewhere grouped as Upper Old Red Sandstone. They consist of conglomerates made up of porphyrite and Silurian greywacke. The overlying rocks are described in much detail, many sections being given to show the position of the principal beds of limestone, coal, etc. Separate chapters are devoted to the Faults, and to the Palæontology, the fossils having been identified chiefly by Messrs. G. Sharman and E. T. Newton. Other chapters are devoted to the Igneous rocks, to Glacial Phenomena, Post-Glacial deposits, and to the Physical History of the district. The Economic deposits, Springs, Mineral Waters, etc., are duly noticed, and in Appendices there is an account of the Bibliography, together with a Glossary of Local Terms, and Records of Borings and Sinkings.

5. "The Geology of the Country around Halesworth and Harleston." By W. Whitaker, F.R.S., and W. H. Dalton. 8vo. pp. vi. and 41. (London, 1887.) Price 1*s.*

In this Memoir accounts are given of the Upper Crag (which is rarely fossiliferous in the area), of Chillesford Clay, Pebbly Series, Glacial and Post-Glacial Drift, and Alluvium. The deposits which have attracted most attention are those included as Post-Glacial, the term being used to imply that the beds are newer than the Glacial Drifts of the district. These are the famous Hoxne deposits, which have yielded many Palæolithic implements. Their precise age with reference to the newer Glacial deposits of the north of England may be regarded as an open question: but Mr. Dalton remarks that "The mere presence of land and freshwater shells, bones, and plants would suffice to disprove this correlation with any part of the Glacial series, which is wholly of marine origin." We presume he refers to the Glacial Drifts of Norfolk and Suffolk, but that they are *wholly of marine origin* is very far from being an accepted dogma.

A number of records of well-sections conclude this work; these give accounts of the London Clay, Reading Beds, and Chalk, which are not exposed at the surface.

6. "The Geology of Southwold and of the Suffolk Coast from Dunwich to Covehithe." By W. Whitaker, F.R.S. 8vo. pp. 87. (London, 1887.) Price 2*s.* 6*d.*

Although the area described in this Memoir is a small one (being less than 50 square miles), it is one of considerable interest to students of Pliocene Geology. The cliffs of Dunwich, Easton

Bavent, and Covehithe furnish sections of the Upper Crag (including the Chillesford Beds); these strata are overlaid by a "Pebbly Series," and the question of their precise equivalents in other parts of the country is a debatable one; while above all there are accumulations of Glacial Drift. A well-boring at Southwold, made in 1886–1887, has thrown much light on the underground geology, for it has proved the position of the Chalk at a depth of 323 feet; this is overlain by 70 feet of Reading Beds, 68 feet of London Clay, 147 feet of Crag, and 37 feet of the Pebbly Series.

The thickness of the Crag, as remarked by Mr. Whitaker, is the greatest yet recorded in England, and shows, together with the information obtained through wells at Leiston, Saxmundham, and Beccles, that the formation has a more important development than was suspected a few years ago. Whether this great thickness of Crag should be classed with the Norwich or Red Crag matters little, for, as Mr. Whitaker remarks, they are one formation, and "no useful purpose would be served by troubling about such a question." There is, however, no evidence to show that the highest stage of the Norwich Crag series (such as that represented in the fossiliferous beds of Weybourn and the Bure Valley) is here present, unless it be represented in portions of the "Pebbly Series" that are fossiliferous near Southwold.

The "Pebbly Series," however, presents many difficulties. Much of what is now grouped under this name was originally regarded as Middle Glacial by Messrs. S. V. Wood and Harmer in their Map and Sections of the Crag District, and although Mr. Wood subsequently modified his views, there does not appear to be any definite evidence for the change, and an examination of the Survey Map is not calculated to dispel the notion. These difficulties in correlation are apparent to any one studying the Newer Pliocene and Glacial Deposits of East Anglia, and they are very fully and fairly stated by Mr. Whitaker. He is disposed to regard the Pebbly Series as belonging to one division, and he leaves it an open question whether it should be regarded as Glacial or Pliocene. The shells found in the beds at Southwold are all species known to occur in the Crag; but neither there nor at Dunwich is the Crag separated from the Pebbly Series by the Chillesford Beds which are present in many localities.

On the other hand, where the mass of the Pebbly Series rests on the Chillesford Beds, as seen in the Cliff-sections of Easton Bavent and Covehithe, there is a marked line of erosion between them; while in a section at Henham Park Wood (drawn by the late Mr. S. V. Wood, jun.), the Pebbly Beds are shown to rest on the Chillesford Clay, and tongues of the latter which penetrate the overlying beds are said to have been "lifted up." In reference to this Mr. Whitaker remarks that "The lifting up of masses of this clay and the forcing under them of wedges of the pebbly beds is an occurrence of great interest," and "seems to point also to some lapse of time between the two deposits." We feel, however, some hesitation in adopting the explanation, which is suggestive of Glacial action, for there is no Boulder-clay present.

We should mention that a detailed account is given of the Cliff sections, and this is admirably illustrated by a coloured diagram drawn to scale. The accounts of the coast-deposits and of the waste of the cliffs are also of much interest, careful calculations showing that at Covehithe the annual loss of land is between 18 and 19 feet! Records of well-sections, and a list of the fossils, are also given in this Memoir.

7. "The Geology of the Carboniferous Limestone, Yoredale Rocks, and Millstone Grit of North Derbyshire." By Prof. A. H. Green, F.R.S., Dr. C. Le Neve Foster, and J. R. Dakyns. Second edition, with additions by Prof. Green and A. Strahan. 8vo. pp. xv. and 212. (London, 1887.) Price 5*s*. 6*d*.

A new edition of this Memoir (which was published originally in 1869) has long been wanted, for the district is one that offers many attractions to the geologist. Some changes are made in the classification of the Millstone Grit and Yoredale Rocks. The portion relating to the Drift has been enlarged, and a small map has been given (p. 97) to show the glaciation of the north-west of England. There is also much additional information about the Caves, Springs, etc., and on the subject of Mining. The list of fossils from the Carboniferous Limestone has been revised, and a Bibliographical List has been appended.

8. "The Geology of the Country around Kendal, Sedbergh, Bowness, and Tebay." By W. Talbot Aveline, and Prof. T. M'K. Hughes. Second edition by A. Strahan. Parts by J. R. Dakyns and R. H. Tiddeman. 8vo. pp. 94. (London, 1888.) Price 2*s*.

The former edition of this Memoir was published in 1871, since then the area has been re-surveyed for Drift. A great deal of new information has been obtained respecting the Volcanic series of Borrowdale, the Coniston Limestone Series, the Stockdale Shales, the Carboniferous rocks, the Shap granite, and the Glacial phenomena. Full lists of fossils are given, and there is also a Table showing the distribution of the Graptolites, by Prof. Lapworth.

II.—Two Works on the late Professor Heer.

1. Oswald Heer: Lebensbild eines Schweizerischen Naturforschers: I. Die Jugendzeit, von Justus Heer; 144 pages, with a Photographic Portrait. II. & III. O. Heer's Forscherarbeit und dessen Persönlichkeit, von C. Schröter, unter Mitwirkung von Gustav Stierlin und Gottfried Heer; 543 pages, 8vo. with a Coloured Plate and many Woodcuts taken from "The Primæval World of Switzerland." (Zurich, P. Schulthess, 1887).

THE great influence exerted by the late Prof. Heer on different branches of Natural History, and especially on the development of palæobotany, has very naturally given rise to the work mentioned above. It contains a sketch of Heer's life and an analysis of his many different works. The author of the first part is Heer's brother, the late Rev. Justus Heer, who gives a very

interesting sketch of the early years of the great palæobotanist. His love for nature began in his early youth, which was passed in the little Alpine village of Matt, of which his father was the clergyman. He first studied the flora and fauna (more especially the insects) of the districts near his home, and subsequently extended his researches to the higher regions of the Alps. He became an intrepid and skilful climber, and the numerous botanical and entomological discoveries made by him in these little accessible regions attracted the notice of many well-known scientific men of his native land. In deference to his father's wish, he had, however, to give up his inclination for scientific pursuits, and betake himself to the University of Halle to prepare for a clerical career. After returning to Switzerland, he declined the offer of a life-long appointment as clergyman, and preferred rather to accept a temporary engagement to arrange and determine the large entomological collections of Escher-Zollikofer; thus definitely undertaking a scientific career.

The second and third parts of the volume are devoted to a critical review of Heer's scientific work, and a sketch of his personal character; the former is more especially interesting since the matters treated are still of the first importance. Dr. Schröter refers first to Heer's work on recent plants, more particularly regarding their geographical distribution, both generally and in the different regions of the Alps. Late in life, Heer again turned his attention to the origin of the Alpine flora, as shown in his posthumous treatise "Die nivale Flora der Schweiz." Equally valuable are his researches on the ancient history of still existing plants, and his paper on the plants of the ancient lake-dwellings (Die Pflanzen der Pfahlbauten) is a genuine classical treatise. Heer's many other botanical works cannot even be mentioned here.

Then comes a chapter, written by Dr. Stierlin, giving a review of Heer's contributions to the knowledge of recent and fossil insects. It is an interesting fact that Heer treated the beetles of Switzerland from precisely the same points of view as the plants; regarding not only their systematic position, but their geographical distribution as well. He was therefore very familiar with the laws of the geographical distribution of plants and animals when he commenced his studies on the ancient floras and insect faunas of the globe. His remarks on the habits and intellectual powers of a species of ant from Madeira (*Œcophthora pusilla*) give great credit to his keen faculty of observation.

Heer's contributions to fossil entomology are indeed astonishing. They will be best understood from the fact that at the time he began his work only about 200 species of fossil insects were known; and he was able from Switzerland alone to describe more than 1000 fossil species, of which 143 were from the Liassic strata of Schambelen, and 876 species from Tertiary beds of other parts of the same country. Besides these, he described a great number of species from the Tertiary deposits of Radoboj and Aix; from the Rhætic beds of Scania, as well as from the Arctic regions, etc. Any one who has read the "Primæval World of Switzerland" will call to mind the

number of ingenious conclusions which Heer has drawn from the presence of these creatures in the rocks—conclusions which could only have been arrived at by one who was thoroughly familiar with the habits of existing forms.

Dr. Schröter devotes several chapters to the most important part of Heer's life-work—namely, his contributions to fossil botany. After passing in review the work done in this branch of science before Heer contributed to it, he proceeds at once to the consideration of the important question as to the reliability of the determinations from dicotyledonous leaves. It has been generally supposed that Heer was himself satisfied as to the validity of determinations thus based; but, as Prof. Schröter points out, this is by no means the case. Heer has thus expressed his views on the point: "In those instances, where the form of the leaves and their nervation are very characteristic, we may, at least with great probability, determine the plant from them; in other cases, its systematic position must be regarded as doubtful until other portions of the plant have been discovered, by means of which the characters drawn from the leaves are corroborated. Leaves of this latter category are of little value from a systematic point of view, but they may, notwithstanding, be of great service in the determination of the geological horizon in which they occur. The systematic position of *Myrica dryandræfolia*, Brongniart, was thus for a long time doubtful. Brongniart himself referred the leaves to *Comptonia*, Ettingshausen to *Dryandra*, whilst Saporta was able at last to show that Brongniart's opinion was correct. But although it was for a long time doubtful whether the leaves belonged to *Myricaceæ* or to the *Proteaceæ*, they nevertheless did good service as characteristic fossils."

Dr. Schröter is quite right in stating that it is unfortunate for the credit of phytopalæontology that names must be given even to those leaves of which the systematic position cannot be ascertained. The mischief would, however, to a certain extent, be avoided by the adoption of the method proposed by the reviewer, that no fossil leaf from strata older than the Pliocene should be placed under an existing genus unless its generic relationship is sufficiently proved by other evidence, in addition to that of the leaf itself. When this cannot be shown, the leaf should either be given an independent generic name, such as *Credneria*, *Dewalquea*, *Protophyllum*, etc., or a name compounded of an existing genus with the suffix *phyllum*. A name of this character would not exclude the idea that the leaf in question might belong to the existing genus, it would only indicate that its congeneric identity had not been proved. If all fossil dicotyledonous genera were revised on this system, we should find that most of the Cretaceous forms would be brought under *Magnoliphyllum*, *Populiphyllum*, *Lauriphyllum*, *Platanophyllum*, etc., instead of *Magnolia*, *Populus*, *Laurus*, and *Platanus*. Of Tertiary plants, a greater percentage would be brought within existing genera, but others would have to retain the provisional suffix *phyllum*. It might even happen that both generic names could be used for different species from the same deposits, as, for example, *Acer arcticum* and

Aceriphyllum inæquale. Then we should know at once that the former species had been proved to belong to the genus *Acer*, whilst the generic position of the latter was still uncertain. In this way the palæobotanist would be able to express the precise degree of our knowledge of a fossil plant.[1]

Dr. Schröter is not an uncritical admirer of everything which Heer has done, but whilst expressing the opinion that Heer had gone too far in determining genera from dicotyledonous leaves, he gently remarks that it has nevertheless been fortunate for science that he had the courage to proceed as far as he did, for otherwise a great number of fossil leaves, which have been rightly determined, and which have proved of the greatest value in furthering our knowledge of the geographical distribution of plants, and of the climates of former epochs, would have been either overlooked or not described. And even supposing that in some cases Heer's determinations of fossil leaves have been insufficiently based, these are more than counterbalanced by the importance of those correctly worked out. According to Dr. Schröter, the total number of new species described by Heer amounts to 1947, and, in addition to these, he has described numerous forms to which names had been already applied by others. These descriptions of fossil plants were accompanied by as many as 704 plates. Heer had indeed the satisfaction to find that the merits of his works were acknowledged by most competent judges, amongst others by Sir Joseph Hooker, who pronounced, as his "candid opinion," that at least two-thirds of Heer's determinations of fossil genera and families were quite correct, and that those correctly determined included nearly everything of importance. Even Lyell was fully convinced of the correctness of Heer's determinations of Tertiary plants.

Under these circumstances it is probable that the attacks made, from time to time, on Heer's methods and results, owe their origin either to imperfect knowledge, or to a misunderstanding of what he has done. Of course, since the time when Heer wrote there have been great advances made in palæobotany, as in every other science, and it is not surprising, therefore, that the methods he followed should now be partly supplanted by better ones. But if we are to condemn every honest worker of a previous age simply because his methods do not agree with our own, who would then escape condemnation? There is no doubt that Heer, in common with every other scientific writer, has made mistakes; but these are so much more than counterbalanced by the excellent work he has done, that it would be decidedly unfair to dwell only on the former, without taking the latter into account.

Much has been written lately on the question whether certain deposits, pronounced by Heer to be of Miocene age, might not, in reality, belong to the Eocene. The question is still undecided; but even if some of these deposits should ultimately prove to be of Eocene age, it must not be forgotten that but little was known of

[1] For further details compare the paper by the reviewer in the "Botanisches Centralblatt," 1886, vol. 25, Ueber die Benennung fossiler Dikotylenblätter.

Eocene floras when Heer wrote, and that the present abundant materials for comparison did not then exist.

Want of space prevents our giving an exhaustive analysis of Dr. Schröter's work. Besides a review of Heer's "Primæval World of Switzerland," so well known to the scientific world of England, and an exhaustive criticism of the "Flora fossilis arctica" (seven vols. 4to. 398 plates, 1868–83), it treats of Heer's contributions to several scientific problems. We may here call to mind that Heer was the first palæobotanist who expressed the opinion that the polar regions had been the centre of distribution for a multitude of plants, especially since Cretaceous and Tertiary times, and this view was developed and defended in many of his works. It is therefore very annoying, Dr. Schröter says, to find a statement in "Nature,"[1] in which Heer is specifically excluded from the list of naturalists who are said to have rendered services to the theory of the migration of plants from the polar regions.

Dr. Schröter gives, further, an exposition of Heer's contributions to the Climatology of ancient epochs; of his phylogenetical studies of different genera and families, and of his position towards the theory of evolution. Heer has generally been regarded as an antagonist to this theory, but this is so far from correct, that he should rather be considered as one of the precursors of Darwin. Already, in 1855, Heer pronounced the opinion that species owed their origin to other species, and he may therefore be looked upon as an evolutionist (compare also Life of Lyell, part ii. p. 246), even though he did not believe in the *gradual* development of species, but considered that the transitional changes were *sudden*, and occurred during certain *short* periods.

The great productivity of Heer as a scientific author, and the diversity of subjects he treated, make it very difficult to obtain a full comprehensive view of his scientific achievements. Next to consulting his original works, the present volume affords us the best idea of the entire life-work of the great palæobotanist of Zurich. No doubt Dr. Schröter's task has been a very difficult one, and there is therefore the more reason to congratulate him on having accomplished it in such a successful manner. A. G. Nathorst.

2. Oswald Heer: Bibliographie et tables iconographiques, par Godefroy Malloizel; precédé d'une notice biographique par R. Zeiller; avec un portrait d'Oswald Heer. 8vo. pp 176. (Stockholm, F. & G. Beijer, 1888.)

The volume now under consideration may be said to complete and supplement that by Dr. Schröter, noticed above. Whilst this latter gives a sketch of Heer's life, and a general analysis of his scientific works, the present volume is intended to facilitate references to the works themselves. The biographical sketch by M. Zeiller is limited to ten pages; the rest of the volume by M. Malloizel, Sub-Librarian of the Museum of Natural History, Paris, contains a com-

[1] May, 1879, p. 12.

plete list of the various works, articles and notes published by Heer, arranged according to their dates of publication, which extend from 1832 to 1884. This list comprises from 270 to 280 titles, and it is followed by lists of the fossil animals (except the insects) in "Die Urwelt der Schweiz"; of the insects figured in Heer's various works, and of all the fossil plants described and figured by Heer. As the references include the page, plate, and number of figure for each species, it is evident that the work will prove of immense service to palæobotanists and others desirous of consulting Heer's works. I can state from my own experience that it has already been of much service to me, and a great saving of time and trouble, and M. Malloizel deserves the thanks of all palæobotanists for undertaking the tedious task of preparing this compilation.

A. G. Nathorst.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 25, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "Report on the Recent Work of the Geological Survey in the North-west Highlands of Scotland, based on the field-notes and maps of Messrs. Peach, Horne, Gunn, Clough, Hinxman, and Cadell." Communicated by A. Geikie, LL.D., F.R.S., F.G.S., Director-General.

At the outset a review was given of the researches of other observers, in so far as they forestalled the conclusions to which the Geological Survey had been led. Reference was made to the observations of Macculloch, Hay Cunningham, C. W. Peach, and Salter; to the prolonged controversy between Sir Roderick Murchison and Professor Nicol; to the contributions of Hicks, Bonney, Hudleston, Callaway, Lapworth, Teall, and others. It was shown that Nicol was undoubtedly right in maintaining that there was no conformable sequence from the fossiliferous quartzites and limestones into the eastern schists. It was also pointed out that the conclusions of Professor Lapworth regarding the nature and origin of the eastern schists involve an important departure from Nicol's position, and are practically identical with those obtained independently by the Geological Survey.

The results of the recent survey work among the Archæan rocks may be thus summarized:—(1) the eruption of a series of igneous rocks of a basic type in which pegmatites were formed; (2) the development of rude foliation in these masses, probably by mechanical movement, and their arrangement in gentle anticlines and synclines, the axes of which generally run N.E. and S.W.; (3) the injection of igneous materials, mainly in the form of dykes, into the original gneisses, composed of (*a*) basalt rocks, (*b*) peridotites and palæopicrites, (*c*) microcline-mica rocks, (*d*) granites; (4) the occurrence of mechanical movements giving rise to disruption-lines trending N.W. and S.E., E. and W., N.E. and S.W.; (5) the effects of these movements on the dykes were to change the basalt-rocks into diorites

and hornblende-schists, the peridotites and palæopicrites into talcose schists, the microcline-mica rocks into mica-schists, and the granites into granitoid gneiss; (6) the effects on the gneiss resulted in the formation of sharp folds trending generally N.W. and S.E., the partial or complete reconstruction of the original gneiss along the old foliation-planes, and finally the development of newer schistosity more or less parallel with the prominent disruption-lines.

There is an overwhelming amount of evidence to prove that all these various changes had been superinduced in the Archæan rocks in Pre-Cambrian time.

After reviewing the facts bearing on the denudation of the Archæan land-surface, the order of succession and thickness of the Cambrian strata were given, from which it is apparent that the deposits gradually increase in thickness as we pass southwards from Durness to Loch Broom.

Prior to the deposition of the Silurian sediments the Cambrian strata were folded and extensively denuded. By these means various Cambrian outliers were formed far to the east of the present limits of the formation.

The order of succession of the Silurian strata along the line of complicated structure from Eriboll to Ullapool was described, reference being made to the further subdivision of the "Pipe-rock" and the Ghrudaidh Limestones (Group I. of Durness section). None of the richly fossiliferous zones of Durness is met with along this line, as they occupy higher horizons. An examination of the fossils recently obtained by the Geological Survey from the Durness Limestones confirms Salter's conclusions that they are distinctly of an American type, the Sutherland quartzites and limestones being represented by the Potsdam Sandstones and Calciferous Sand Group of North America.

After the deposition of the limestones, the Cambrian and Silurian strata were pierced by igneous rocks, mainly in the form of sheets, producing important alterations in the sedimentary deposits by contact-metamorphism, the quartzites becoming crystalline, and the limestones being converted into marble.

When this outburst of volcanic activity had ceased, terrestrial displacements ensued on a stupendous scale. By means of powerful thrusts the Silurian strata were piled on each other, and huge slices of the old Archæan platform, with the Cambrian and Silurian strata resting on it, were driven westwards for miles. With the view of illustrating the extraordinary complications produced by these movements, a series of horizontal sections was described drawn across the line between Eriboll and Ullapool.

The evidence relating to regional metamorphism was next referred to, from which it is obvious that with each successive maximum thrust there is a progressive amount of alteration in the displaced masses, as the observer passes eastwards to the higher thrust-planes. Eventually the Archæan gneiss is so deformed that the Pre-Cambrian foliation disappears and is replaced by new divisional planes; the Cambrian grits and shales are converted into schists; the Silurian

quartzites into quartz-schists; the limestones become crystalline; the sheets of intrusive felsite, diorite, and granitoid rock pass into sericite schist, hornblende-schist, and augen-gneiss respectively.

The researches furnish a vast amount of evidence in support of the theory that regional metamorphism is due to the dynamical and chemical effects of mechanical movement acting on crystalline and clastic rocks. It is also clear that regional metamorphism need not be confined to any particular geological period, because in the N.W. Highlands, both in Pre-Cambrian time and after the deposition of the Durness Limestone (Lower Silurian), crystalline schists and gneiss were produced on a magnificent scale.

2. "On the Horizontal Movements of Rocks, and the Relation of these Movements to the Formation of Dykes and Faults and to Denudation and the Thickening of Strata." By William Barlow, Esq., F.G.S.

The paper commenced with a description of some horizontal movements of rocks caused by gravitation; and the author quoted Mr. C. E. Dutton's descriptions of the Grand Cañon District, especially noting the fact that between succeeding escarpments the strata dip slightly from the crest of the one below to the foot of the next above, and that whilst the strata of the median parts of each terrace are nearly horizontal, the inclination increases as we approach the escarpment of the next higher terrace, and also that Dutton observed indications of a slight elevation of the unloaded strata within the denuded elliptical area known as the "San Rafael Swell." After alluding to Dutton's suggestion that the phenomenon referred to is analogous to the action of creeping in deep mines, the author discussed the nature of such "creeps," which he defined as the thickening of the parts of beds from which a load of superincumbent rock has been lifted, caused by a thinning of the adjoining parts which remained loaded, some of the substance of the latter having been squeezed out to furnish the material for the thickening, and suggested that some of the subsidiary plications found on the flanks of mountains are caused by the thrusts arising from creeps. He also paralleled the fissures in the precipices of the Grand Cañon District with those produced in the pillars of coal owing to the strain induced by the slight inequality in the yielding of the bed supporting it, and pointed out how such fissures would facilitate denudation, giving instances recorded by Dutton, and that an appreciable influence might be thus produced in all cases of mountain-denudation.

The author next considered the case of a body of molten rock below a considerable mass of solid rock. The pressure upon the molten mass would cause movement to take place towards the point where the superincumbent weight was least, provided that absolute equilibrium did not exist. The overlying rocks being more or less plastic, some horizontal movement of the solid rocks at the confines of the molten mass, and subjected to its influence, might be looked for. Any such yielding would tend to draw apart the solid crust resting upon the molten rock, and the ground would open along lines of weakness, such as would be produced by the presence of joints, the crust in some cases breaking up into larger or smaller fragments.

When a large mass of molten matter occurred near the surface, and a fissure was produced in the way described, the weight of the ruptured crust would, if the plastic mass beneath were sufficiently liquid, cause the latter to rise in the fissure, producing dykes. Attention was called to the fact observed by Dutton that basaltic vents frequently occur on the brink of cliffs, but never at their bases; also to the existence of dykes having a strike parallel to the Colorado River. In most cases the vertical fissures which received the molten rock would begin to open from below, and the upper strata might altogether escape rupture.

The author discussed the case of the Henry Mountains, and explained the formation of flat-topped and flat-bottomed dykes according to his views. He next called attention to the influence which the motions of the rocks had exercised in determining directions of drainage when fissures left unfilled became occupied by streams. He next alluded to river-valleys, the existence of which had been accounted for by "antecedent" and "superimposed" drainage, and suggested difficulties in the way of accepting the explanations hitherto advanced, and considered them to be instances of fissuring produced by movements of the strata due to the pressure of a mass of molten or highly plastic rock spreading laterally.

After treating of the formation of faults with normal hade, which he referred in some cases to rupture of the solid crust by the spread of a vast mass of viscous matter lying beneath it (the faults being sometimes replaced above by monoclinal folds), he referred in conclusion to the extent of the horizontal compression of the earth's superficial crust, which is seen to be associated with the elevation of mountain-ranges, and called attention to some evidence that the thickening of the strata caused thereby would be more considerable and general than ordinarily supposed.

3. "Notes on a Recent Discovery of *Stigmaria ficoides* at Clayton, Yorkshire." By Samuel A. Adamson, Esq., F.G.S.

The specimen described was obtained in November, 1887, from the beds between the Better-bed Coal and the Elland Flagstone of the Fall-top Quarries of Messrs. Murgatroyd. The author gave measurements of the specimen, and compared them with those of another found in the same quarry in 1886, and now preserved in the Owens College, and with those of a third obtained in an adjoining quarry.

CORRESPONDENCE.

ROUNDING OF PEBBLES BY ALPINE RIVERS.

Sir,—Mr. Irving's remarks in your last number appear to call for a few words in reply. As my paper was entitled "On the Rounding of Pebbles by Alpine Rivers," I fail to see that I was bound to discuss other modes of forming pebbles, unless they seriously interfered with the inductions which I was attempting to draw. Hence, I did not mention "the weathering of débris on the mountain sides," because, so far as that had a bearing on my subject,

it strengthened my argument, which was to show that a respectable pebble was not easily made by running water, and because, in the case of the rocks with which I was dealing, the rounding mentioned by Mr. Irving is, as a rule, a very secondary and subordinate matter.

(1.) Every one knows that certain rocks become tolerably rounded by mere aërial waste, but the débris which reaches Alpine torrents (in the districts of which I spoke) is commonly angular; and this is equally true of the material to which my inferences applied. I may add that I believe few things are more important in attempting to reason inductively from observed facts than to be careful in preserving a due relation between quantities of the first and second order of magnitude (as they are called by mathematicians). Overmuch precision of statement and an elaborate parade of small details interfere with our sense of proportion, and there is great danger, if you look at a sprat for too long a time, and from too near a point of view, that you may at last fancy it a whale.

(2.) In regard to "the scouring action of sand," I cannot pretend to say how much is done by the knocking of the pebbles together, and how much by the friction of passing sand; but I certainly cannot make the distinction which Mr. Irving attempts to do. All the rivers of which I spoke transport quantities of sand as well as pebbles in all parts of their course, though it is only in the lower part that they can deposit much of the former. However, as it takes a very long journey to remove the angles from a grain of sand, I have my doubts as to its conspicuous efficiency as a fashioner of pebbles out of pieces of hard rock, and if Mr. Irving alludes to the action of sand on pebbles which but rarely travel, then I think it would tend to flatten rather than to round them.

(3.) In regard to the general question raised, viz. the origin of the pebbles and other materials of the Bunter group, space will not permit me to enter into details, so I must forbear to criticize minor but not unimportant points in Mr. Irving's letter, such as "the pebble-beds proper being quite *local*," a statement which is only true if a most liberally extended sense be given to the last word. But I express a fundamental dissent by asking whether there is any evidence at all in favour of the Bunter being a marine deposit, and still more a deposit in a sea where, according to the ordinary rules, strong coast currents or a rolling surf would be likely to exist. All I can say is that the Bunter as a whole is remarkably unlike every admitted marine formation which I have ever examined, while it presents a strong resemblance to such deposits as parts of the Old Red Sandstone, some beds in the Lower Carboniferous of Scotland, and the Nagelflue of the Alps: deposits, which most geologists agree in considering more or less fluviatile: nay, allowing for a slight difference in colour and hardness, the Bunter pebble-beds of Central England (I said nothing about Southern England) are indistinguishable from many of the old sub-Alpine river-drifts which I have repeatedly examined.

T. G. Bonney.

GRAPHITE AT KENDAL.

Sir,—A few days ago, in digging a grave in the cemetery at Kendal, a piece of graphite weighing about five ounces was found in the Glacial Drift of which the ground is composed. The cemetery is at the southern base of the Castle Hill, a large drumlin containing boulders and gravel, of Shap granite, Kirkby Moor flags (Ludlow), Ash (Borrowdale series), and other rocks. The granite is only found on the northern half of the hill. The other rocks might be derived from the valleys which converge on Kendal or in the line of boulder flow from Shap.

Unfortunately the graphite was not found in undisturbed drift. It lay a short distance above the lid of the coffin of an earlier interment made about 17 years ago. But it was so coated with soil that if it had not been accidentally scratched with the spade in digging, the sexton would not have noticed anything peculiar about it, and it is very probable that it may have been thrown out when the original grave was made, and reburied when the grave was filled in.

That it was brought by other than nature's agency is not likely. It was not usual at the date of the earlier interment to place ornaments on the graves, and the piece of graphite is not an article likely to be used for that purpose.

Probably therefore it has been brought down with the drift from some deposit of graphite to the North or North-East. It is not likely to have come from Borrowdale; for I know of no instance of the discovery of any rock which can be distinctly traced to that region in the Kendal drift.

Graphite being rare and destructible, I thought it might be of interest to record the discovery. Geo. Crewdson.

St. George's Vicarage, Kendal,
9*th May*, 1888.

THE METAMORPHIC ROCKS OF SOUTH DEVON.

Sir,—In reply to Miss C. A. Raisin's letter (see Geol. Mag. p. 190) the chloritic rock is a little on the north (or more correctly the north-west) side of Prof. Bonney's fault-line where first indicated at the commencement of his "true schists." These schists are also in their line of strike, on the south side of the chloritic rock. A recent visit has, however, enabled me to find these chloritic rocks still further north, across the stream on the north flank of the valley, so that the stream cannot be regarded as marking a line of fault, which from physical appearances it might seem to do.

59, Fleet Street, Torquay. Alex. Somervail.

OBITUARY.

WALTER KEEPING, M.A.,

BORN JANUARY 6, 1854; DIED FEBRUARY 22, 1888.

Mr. Walter Keeping has for six years been lost to his friends and to science. In the vigour of early manhood he was somewhat

suddenly struck down by a form of paralysis, well known to medical men, which seldom spares its victim so long as in the present case. Previous to those six years we see him in full intellectual activity, after a distinguished University career and a period of further training as a teacher himself, settled down in charge of the magnificent collections in the York Museum, and giving promise of much valuable work for science.

His early education was carried on alongside of work, which he had to perform in positions of more or less importance and trust, ending in the post of assistant to his father in the Woodwardian Museum. At the age of 19 he won a Scholarship at Christ's College, and in due course graduated, obtaining a distinguished position in the First Class of the Natural Sciences Tripos of 1877. He continued to work in the Woodwardian Museum until he was appointed Professor of Natural Science in the University College of Wales at Aberystwith. His quickness of observation always attracted him to the study of the Geology of the district in which he resided.

The Lower Greensand of the neighbourhood of Cambridge, with its derivative fossils and rocks, as well as those which belonged to the age of the deposit, had received great importance from the economic value of the phosphatic nodules it contained, and early engaged his attention. It was then beginning to be the fashion to speak of it as Neocomian. In 1875 he published a paper in the Geological Magazine on "The Occurrence of Neocomian Sands with Phosphatic Nodules at Brickhill." Five years later he contributed a paper to this Magazine on "The Included Pebbles of the Upper Neocomian Sands of the South East of England, especially those of the Upware and Potton Pebble-beds"; and in 1883 the Sedgwick Prize was awarded him for his Essay upon "The Fossils and Palæontological Affinities of the Neocomian Deposits of Upware and Brickhill."

He was especially interested in the Echinodermata, and in 1876 and 1878 contributed some valuable Palæontological Notes to the Journal of the Geological Society in his papers on Palæozoic Echini; on the Discovery of *Melonites* in Britain; and on *Pelanechinus*, a new genus of sea-urchins from the Coral Rag.

On his appointment to the Chair of Natural Science at Aberystwith, he turned his attention to the geology of the surrounding district, which he described in this Magazine in 1878, and in a paper on "The Geology of Central Wales," read before the Geological Society in 1881.

These and various other notes and papers, recording observations made by him in the British Isles and on the Continent, show a keen perception of details and a power of generalization, which led his friends to anticipate for him a long career of distinction and useful work. But soon after his appointment to the Curatorship of the York Museum, his health broke down, and after six years painful illness, he passed away in February, 1888.

Thos. McKenny Hughes.

Fig. 1.

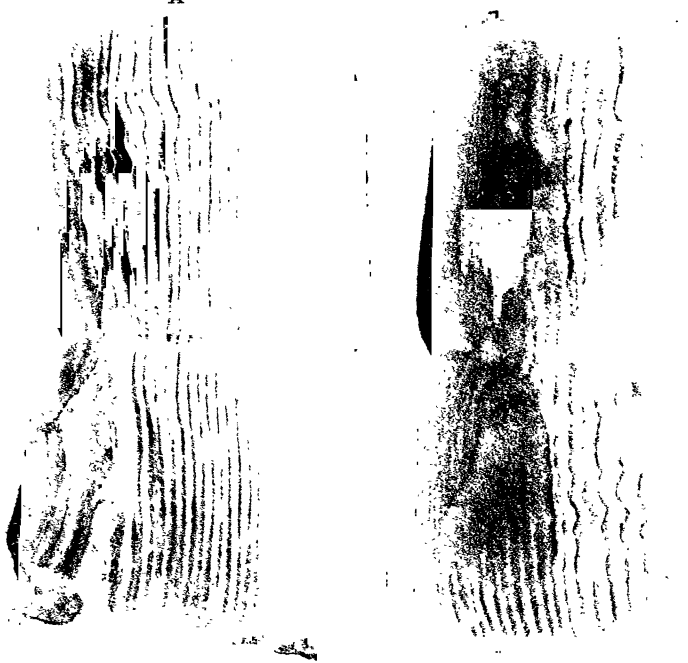
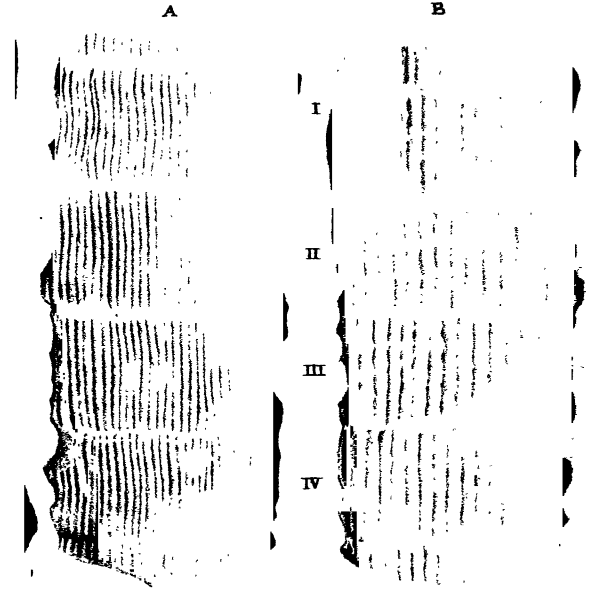


Fig. 2.



G. M. Woodward del. et lith.

West, Newman & Co. imp.

Calamites undulatus, *Sternb*

THE
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ORIGINAL ARTICLES.

I.—Woodwardian Museum Notes. On *Calamites undulatus* (Sternb.).

By Albert C. Seward, B.A., F.G.S.,
Foundation Scholar of St. John's College, Cambridge.

(PLATE IX.)

At the end of his monograph on the structure of *Calamites*, Prof. Williamson makes the following remark:[1]—"I am disposed to regard all existing specific names and definitions as worthless. They separate things that I believe to be identical, and confound others that are obviously distinct." The specimen described below affords an interesting example in support of this view.

Sternberg founded the species *undulatus* on specimens with undulating ribs, which he figured in the "Flora der Vorwelt."[2] In the "Prodrome d'une Histoire des végétaux fossiles," Brongniart includes this species in his list of *Calamites*. The same author describes *C. undulatus* in his later work,[3] but suggests, however, that it may be a variety of *Calamites Suckowii.*

Ettingshausen[4] recognizes the impossibility of separating the different species of *Calamites*, and includes *Calamites undulatus*, *C. Suckowii*, *C. æqualis*, and many others under one species, *C. communis.* Schimper[5] considers the flexuous character of the ribs and furrows of *Calamites* to be due to vertical pressure, and attaches no specific importance to it.

Dawson[6] retains the species *undulatus*, because certain specimens show the reticulate markings on the surface similar to those represented in Brongniart's figures; the undulating character of the ribs he considers may perhaps be an indication of vertical pressure.

Mr. Kidston[7] does not include the species in his catalogue; he

[1] Phil. Trans. Royal Soc. 1881, On the Organization of Fossil Plants of the Coal-measures, pt. i. *Calamites*, p. 507.

[2] Versuch einer Geognostisch-botanischen, Darstellungen der Flora der Vorwelt. vers. ii. p. 47, pl. i. fig. i. pl. xx. fig. 8.

[3] Hist. des végét. fossiles, tome i. p. 127.

[4] Die Steinkohlenflora von Radnitz in Böhmen, Abhandlungen der Kais. Königlichen Geologischen Reichsanstalt, ii. Band, 3 Abth. No. 3, p. 26.

[5] Traité de Paléontologie végétale, tome i. p. 313.

[6] Report on the Fossil Plants of the Lower Carboniferous and Millstone Grit Formations of Canada, Geol. Survey of Canada, p. 30.

[7] Catalogue of the Palæozoic Plants in the British Museum, p. 25.

regards the flexuous character of the furrows to have been imparted by pressure, any *Calamite* being liable to a bending of its furrows from the same cause.

The specimen now described and figured (Plate IX. Fig. 1. A. B.) is a pyritous sandstone cast of the medullary cavity of a *Calamite*, showing two internodes and one node. I found it in a piece of rock which had been brought to the surface in sinking a shaft at a colliery near Wigan.

Figures 1 A, and 1 B. are opposite sides of the same specimen. In Fig. 1 A, the ribs are perfectly straight and close together. No "infranodal canals" are visible on either side of the specimen. At the left-hand upper corner of Fig. 1 A, the ribs become wide and irregular: in Fig. 1 B, these characters are still further developed, the ribs and furrows now having a decidedly flexuous appearance. In Fig. 1 A, there are about eight ribs in a space of one cm., in Fig. 1 B, three occupy the same space. The length of the specimen is different on the two sides, the side with the straight ribs and furrows being 10 cm. long, and that with the flexuous ribs 9 cm. The ribs and furrows alternate at the node.

On many of the ribs there is a faint median line visible, which is in some parts rendered more conspicuous by the presence of carbonaceous matter. This difference in the breadth of the ribs on the two halves of the specimen is probably due to the original arrangement of the vascular wedges and medullary rays in the living *Calamite*. Prof. Williamson[1] has figured a transverse section of a *Calamite* in which the distance between the woody wedges varies in the two halves of the stem, the medullary rays being narrow in the one half and wide in the other half of the section. In Prof. Williamson's collection of microscopic slides, which I have had an opportunity of examining through his kindness, I have met with other specimens showing the same inequality in the size of the medullary rays on the opposite sides of the section.

In the Woodwardian Museum there is a flattened cast of the medullary cavity of a *Calamite* which shows the same characters still more clearly (Pl. IX. Fig. 2 A, B). The specimen is 18 cm. long and 6·5 cm. broad. On the side shown in Fig. 2 A, the ribs are straight and close together; on the side shown in Fig. 2 B, they are wide and flexuous. "Infranodal canals" are clearly shown on the side with wide and wavy ribs, but less distinctly on the opposite side.

The following measurements show that the internodes on the side with the wide and flexuous ribs are shorter than those with the narrow and straight ribs:—

(Plate IX.)

Fig. 2 A. (Number of ribs per cm. 35.)		Fig. 2 B. (Number of ribs per cm. 17.)	
Length of internode	i. 3·9 cm.	Length of internode	i. 3·5 cm.
..	ii. 4 cm.	,, ,,	ii. 3·7 cm
	iii. 4·2 cm.	,, ,,	iii. 3·0 cm
,, ,,	iv. 3·9 cm.	,, ,,	iv. 3·7 cm.

[1] Phil. Trans. Royal Soc. 1883, On the Organization of Fossil Plants of the Coal-measures, pt. xii. pl. 33, fig. 19.

The first specimen described also showed that the shorter side was that on which the ribs were wide and flexuous. These facts suggest that the flexuous or undulating character of the ribs and furrows may have been induced by a pressure which acted on the living plant and caused it to bend; this would have the effect of widening and crumpling the ribs on the concave side of the bent plant.

II.—Elevation and Subsidence: A Suggestion.

By Professor C. Lloyd Morgan, F.G.S.,
Of University College, Bristol.

It is unnecessary for me to remind the readers of the Geological Magazine of the evidence for elevation and subsidence. For my present purpose it is sufficient to remind them that such elevation and subsidence has been attributed (1) to lateral pressure giving rise to long geo-anticlines and geo-synclines; (2) to expansion and contraction of the underlayers resulting from a rise or a fall of temperature; and (3) to the loading and unloading of the areas of the earth's crust affected. Apparent elevation and subsidence, which we may here neglect, may be due to a rise or fall of the sea-level such as is dealt with by Prof. Hull in a recent communication to this Magazine.

(1.) There can be no doubt that the formation of long geo-clines under the influence of lateral pressure (whether produced by secular contraction, by the screwing of the earth's crust suggested by George Darwin, or otherwise) is a factor in the upheaval and depression of the land. So far as my present purpose is concerned, however, it is only necessary to point out that during the formation of geo-clines under the influences of this lateral pressure there must be a tendency to lessen the vertical pressure on the underlayers beneath a geo-anticline and to increase the pressure on the underlayers beneath a geo-syncline.

(2.) The effects of hydrothermal action on the solid underlayers of the earth's crust would seem to be of two kinds with opposite tendencies. First there is the direct effect of heat with a tendency to expansion. Mr. Mellard Reade has lately ("Origin of Mountain Ranges") insisted on the importance of this factor in the upheaval of the surface. Secondly, there are the metamorphic changes superinduced. The tendency of these is towards condensation or contraction. Which tendency predominates? I doubt if this question can be answered *à priori*. But we are taught that continued sedimentation involves a rise of the isogeotherms beneath the area in which sedimentation is taking place: and we know that there is abundant geological evidence that areas of sedimentation are also areas of subsidence. If, therefore, the changes in the solid underlayers which result from hydrothermal action take place *pari passu* with sedimentation, such evidence as we possess is in favour rather of contraction than expansion. Or if expansion does take place, its effects must be over-mastered by those of some opposing tendency or tendencies. Mr. Mellard Reade would indeed contend that the

uplift manifests itself in the mountain-building at the close of sedimentation. It is difficult, however, to understand why the effects should be so long deferred.

As a corollary from the rise of the isogeotherms beneath areas undergoing sedimentation, we have the depression of the isogeotherms beneath areas undergoing denudation. Here, therefore, cooling should produce contraction, and there should be subsidence. This is not in accordance with observation.

(3.) The intimate connection between subsidence and sedimentation on the one hand and elevation and denudation on the other hand has often been insisted on. This connection may be regarded in two ways. Many geologists maintain that denudation is consequent upon upheaval, and that continued deposition is consequent upon (or is conditioned by) continued subsidence. To others, however (and I count myself among the number), this mode of looking at the facts is not wholly satisfactory. They regard the uplift as in some way the direct result of the lightening of the load by denudation, and the subsidence as the direct result of the added load by sedimentation.

(*a*) Those who hold the latter view would seem generally to attribute the elevation and subsidence to the mere weight of the material added to or removed from a flexible crust resting upon a fluid or viscous substratum.

(*b*) Mr. O. Fisher has suggested (Proc. Camb. Phil. Soc. vol. vi. pt. 1) that water gas may be dissolved in molten rock just as carbonic anhydride may be dissolved in water. Applying Henry's law of the absorption of gases, he considers that on the pressure being relieved from that required for saturation, vesicles of gas may separate from the solvent and may coalesce and rise through the magma expanding as they reach regions of diminished pressure. From this expansion an uplift of the overlying area would result.

(*c*) Prof. Joseph Le Conte has suggested (Nature, vol. xxix. p. 213) that the principle of flotation comes into play. He assumes that the crust of continental areas is more conductive and therefore cools and thickens more rapidly than that of oceanic areas. Thus inequalities of thickness of the crust would result, and by flotation these inequalities, produced in this way on the under side next the liquid substratum, would be reproduced on the upper side next the atmosphere.

Whether such flotation would take place depends upon whether the solid produced by cooling is heavier or lighter than the liquid from which it is derived and on which it rests. Now, although there is a want of agreement as to the amount of contraction which rocks undergo on solidification and crystallization, it is well nigh universally admitted that solidification does involve such contraction and increase of density. The thickened area would therefore tend to subside rather than to be upheaved.

(*d*) It is the object of this paper to suggest other ways in which the loading and unloading of the earth's crust may indirectly bring about subsidence and elevation. I must, however, first ask and seek to answer one or two preliminary questions.

May we assume the existence of a fluid underlayer beneath the superficial crust of the earth? I think we may. From this source volcanic rock would seem to be derived; and in the plutonic rocks we seem to see the solidified crust of the once deeply-buried underlayer. Whether the fluid underlayer be continuous or in more or less isolated reservoirs we cannot say. I shall suggest in the sequel a reason why this substratum should assume the fluid or viscous state.

At what depth beneath the surface of the earth may the plutonic rocks have solidified? It is well known that Mr. Sorby from the microscopical study of the contained crystals concluded that the granites of Cornwall solidified under a pressure equivalent to that of about 50,000 feet (9½ miles) of rock, and that those of the Highlands indicate one of about 76,000 feet; while Mr. Clifton Ward suggested for the granite and granitoid rocks of Westmoreland and Cumberland a mean pressure of 44,000 feet of overload. Commenting upon these results Mr. Prestwich asks, "Are we warranted in supposing that there has been denudation to the extent of removing such enormous masses of rock as this would imply?" and Mr. A. Geikie answers, "It is not probable that any such thick overlying mass ever did cover the granite." (Prestwich, Geology, vol. i. p. 432; Geikie, Text Book, p. 297.)

What was the condition of the potential granite previous to solidification? Nearly all agree that it was rather from hydrothermal solution (at a temperature of, say, 500° C.) than from igneous fusion that the rock solidified. As was long ago pointed out by Bischof, the thinness of the granite veins which branch out into clay slate, the sharpness of the line of junction between the material of the vein and that of the country, and the slight alteration the slate has undergone, point to the mobility of the fluid and render the possibility of gradual solidification from igneous fusion out of the question. (Chem. and Phys. Geol., Paul's Translation, 1859, vol. iii. p. 52.)

What is the amount of expansion under solidification? Bischof's experiments led him to believe that the formation of granite from a liquid magma involved a contraction of 25 per cent. Delesse gave from 3 to 7 per cent. as a more probable estimate. Mr. Mallet found a smaller amount of contraction. In the solidification of plate-glass the contraction was 1·59 per cent. In the case of iron-slag the diminution of volume was 6·7 per cent. Now the sp. gr. of obsidian is from 2·4 to 2·5, while that of granite is (say) 2·65, and that of syenite (say) 2·8. This would seem to point to a diminution of volume by 6 or 8 per cent. on passing from the vitreous to the crystallized condition. Probably therefore a diminution of volume by from 6 to 10 per cent. on passing from the molten to the crystallized condition may fairly be assumed to occur.

It is well known that water expands when it passes into the condition of ice: that ice, say, at −1° C., subjected to pressure melts or is squeezed into the liquid condition: that at high pressures water may remain liquid though the temperature fall several degrees below

zero: and that on relief of pressure such liquid expands into ice. Conversely Amagat has shown (Comtes Rendus, vol. 105, p. 165), that the solidifying point of carbon tetrachloride (a substance that contracts on solidification) may be raised from $-19{\cdot}5°$ C. to $+19{\cdot}5°$ C. by increasing the pressure from 210 to 1160 atmospheres (approximately). I would suggest that similar changes must occur as the fluid or viscous matter in the liquid substratum is subjected to increased or diminished pressure.

Increased pressure would thus tend to squeeze the magma into the solid condition or to induce crystallisation therein. Diminished pressure would tend to allow the partially solidified or crystallized magma to expand into the fluid state.

Take the case of an area undergoing continuous sedimentation. I would suggest that the increased load must tend to squeeze the magma in the underlayers into the solid condition. But in the solid condition the rock occupies less space. Contraction must take place and the contraction is manifested at the surface as subsidence. Furthermore, without committing myself to the acceptance of the theory held by those who attribute subsidence to mere weight, I would suggest to the upholders of that theory that the added weight of the sediment above would entail on this hypothesis an added weight below—that is, if we suppose that the solidified rock adheres to the lower surface of the crust in this region.

In a region undergoing denudation, on the other hand, the lightening of the load would entail the melting of some of the solidified or crystallized magma. Such melting would be accompanied by expansion, manifesting itself at the surface by an uplift.

By the expansion of the melting underlayers tensile stress in the overlying strata would be called into play, and this would throw these strata into a state of tensile strain, thus giving origin to normal faults (to account for the formation of which tensile stress must on any theory be called into play), to the gradual gaping of mineral veins, and to dykes into which the molten matter would be injected by the expansive force.

Without denying as a factor that secular refrigeration on which Mr. Prestwich relies (Geology, vol. ii. p. 216), I would suggest that we have on this hypothesis an efficient primary cause of volcanic eruptions. In this way lava is pressed upwards towards the surface. The expansion of the contained water vapour does the rest of the business.

It is clear that the process I have here suggested would be partially checked on the one hand by the assumed rise of the isogeotherms beneath the subsiding area, such rise, primarily due to sedimentation, being increased by the latent heat rendered sensible during solidification; and on the other hand by the converse depression of the isogeotherms and rendering latent of the heat of fusion beneath areas of denudation.

In the area of subsidence lateral pressure would to some extent be brought to bear in aid of vertical pressure; for it is evident that such subsidence is equivalent to the flattening of a portion of the

(approximately) spherical crust; and such flattening involves compression.

On the view here suggested the earth's crust, instead of being eaten into from below beneath the area of sedimentation, is there relatively thickened; while beneath continental areas of denudation, instead of being thickened, it is eaten into from below. The occurrence of volcanoes on areas of elevation seems rather to lend support to the thinning of the crust in such areas, to its being rent by the stress so as to give rise to volcanic fissures, and, as in America, to fissure eruptions. Mountains on the Uinta and Park types of flexure (Geikie, Text Book, pp. 914–15) are in accordance with this hypothesis.

Concerning mountain ranges of the Jura and Alpine type, where lateral pressure has come so largely into play, I here say nothing. I believe, however, that the principle I am advocating may throw a little ray of light on that most difficult subject.

It may be objected, however, that since liquids transmit pressure equally in all directions, there is no reason why the results of that pressure should be manifested immediately beneath the loaded area. But does not this depend upon the mobility of the liquid? The less mobile the liquid, the greater the tendency for the effects of loading to be concentrated beneath the loaded area. Beneath an area of sedimentation the mobility is much decreased by incipient crystallization. Moreover, we are ignorant how far the liquid substratum is continuous, and how far in disconnected reservoirs. The objection may be more serious than I imagine. I should be glad of the opinion of physicists on this head.

There is another way in which variations of pressure due to the loading and unloading of different areas of the earth's crust may affect the liquid substratum. There can be little doubt that the water contained in the magma is above its critical temperature. Unless, therefore, it is dissolved in the molten rock, as Mr. O. Fisher has suggested, it must be in the state of compressed gas. But such a gas would expand and contract under variations of this pressure. Even if the temperature be not above the critical point, it must be near that point; and the recent researches of Ramsay and Young (Phil. Trans. 1886, pt. i. p. 123; 1887 (vol. 178), pp. 57 and 313), afford ample confirmation of the fact, first observed in 1835 by Thilorier in the case of carbonic anhydride, that near the critical point a substance in the liquid state is even more compressible than in the gaseous state above that temperature.

To sum up. If the upper layers are by lateral pressure thrown into long geo-clines, there will be from this cause an increased pressure beneath the geo-synclines, and a diminished pressure beneath the geo-anticlines. The pressure on the geo-synclinal area will be increased by sedimentation, while that on the geo-anticlinal area will be diminished by denudation. This increased pressure beneath the area of sedimentation may, it is suggested, squeeze some of the underlying magma into a solid state, thus giving rise to contraction and further subsidence. It may also cause the further compression of the water gas contained in the magma, thus giving rise to further

contraction and yet further subsidence. Conversely beneath an area of denudation the decreased pressure may allow some of the solidified magma (kept solid by pressure) to liquefy, thus giving rise to expansion and uplift. It may also permit the expansion of the water gas contained in the magma, and thus give rise to further expansion and uplift. And if, as some geologists have contended, loading and unloading are in themselves sufficient directly to depress or to cause the uplift of a flexible crust, it is clear that subsidence will more readily take place in that area which is not only being loaded above, but is being also thickened below by the condensation of the magma into solid; and that uplift will be more readily effected where the crust is not only being denuded above, but being eaten into by the melting of the underlayers below.

May we not perhaps account on somewhat similar principles for the existence of the underlying liquid or viscous substratum? Mr. Mellard Reade and Mr. Davison have lately independently pointed out that, owing to the cooling and contraction of the earth's crust, there is at some depth beneath the surface a level of no stress, where there is neither lateral compression nor extension, though the rocks are of course subject to the vertical pressure of the overload. Above this level the rocks are subject to compressive stress, and below this level to tensile stress. Picture the earth as composed, onion-fashion, of a number of concentric shells, and fix the attention on one of these shells at a depth of say three miles from the surface. Suppose this shell to be cooling and undergoing contraction. The shrinkage thus brought about will throw the shell into a state of tensile strain (like the oft-washed flannel shirt which has become uncomfortably tight). Now transfer the attention to the fact that the shells interior to the one we have selected are contracting. The shell has to fit a continually diminishing nucleus (like the frock-coat of a man who is rapidly losing flesh). In accommodating itself to this shrinking nucleus, the shell is subject to compressive stress. The question is, then, with regard to any given shell, Which tendency predominates—the compressive stress due to the radial contraction of the sphere, or the tensile stress due to the circumferential contraction of the zone in question? At the level of no stress these tendencies are equal and opposite: above that level compressive stress predominates: below that level tensile stress predominates. According to Mr. Davison (Phil. Trans. 1887) the level of no stress lies five miles deep from the surface; according to Mr. Mellard Reade (Origin of Mountain Ranges, p. 125), it may be taken to lie at a depth of one mile: Mr. Osmond Fisher would reduce this to less than a mile (Phil. Mag. Jan. 1888).

Is it not possible, I would suggest, that throughout the zone of maximum tension, due to circumferential contraction, the rocks may be rendered fluid by relief of pressure?

I have now sketched out in briefest possible outline the suggestion or suggestions I have to offer with regard to elevation and subsidence. I have introduced no calculations of the amounts of upheaval or subsidence. Although it is easy to see that the accumu-

lation of 12000 feet of Coal-measures in South Wales would involve a very material increase of pressure on the underlayers, I am of opinion that numerical calculations in these matters are only too apt to mislead by throwing a glamour of apparent mathematical accuracy over problems concerning which the most noteworthy feature is our profound ignorance. As in so many questions connected with the physics of the earth's crust our data here are too scanty and too indefinite to make numerical calculations of much value. Who shall presume to assign quantitative shares (+ or —) to (1) contraction due to metamorphism in the solid underlayers; (2) expansion of the rocks under increment of temperature; (3) the formation of geo-clines by lateral pressure; (4) contraction and expansion on melting and solidification; (5) the effects of pressure on the water gas contained in the fluid magma; (6) the differential load on a flexible crust? I for one will not. It is presumption enough in me to have ventured at all among the cross-currents of so difficult a sea, where to steer a mathematical course is impossible, and the best one can hope for is to keep one's craft afloat.

III.—Note on the Structure of the Ightham Stone.

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

SOME time since a student of University College, Mr. J. Hale, of Ivy Hatch, brought to me specimens of an extremely hard green sandstone, which he informed me came from the Folkestone Sand stage near Ightham, in Kent. As the microscopic structure proved rather interesting, I lately visited the locality in his company, and had the additional advantage of being conducted by Mr. B. Harrison, of Ightham, so well known for his discoveries of palæolithic implements and for his minute knowledge of the geology of the neighbourhood.

The rock is briefly noticed in Mr. Topley's excellent Survey Memoir on the Geology of the Weald, in the following terms (p. 140):—"At Ightham, near the Roman Camp, is a hard white sandstone five feet thick, a good deal like the 'Greywether' sandstone of the Tertiary, and there is too another kind of stone, not observed elsewhere, a hard and tough dark green sandstone or rather grit. This was not seen in place, but on Ightham Common it is found in large masses, and is there called Ightham Stone and sometimes Firestone, from its being sufficiently hard to strike fire well."

The white sandstone is well exposed at the top of the northern escarpment of the commanding elevation of Oldbury Hill, and its craggy outcrop forms a part of the defence of the ancient camp. The rock appeared to me to vary in thickness and to be somewhat lenticular in its mode of occurrence.[1] Beneath the camp it is underlain by soft ferruginous sand, but a short distance to the south and a few feet below, another mass of sandstone crops out, which however is not nearly so hard. This seems to increase rapidly in thickness, and to be soon full ten feet thick, and perhaps more. On the

[1] Mr. Harrison informs me it is about 140 feet above the top of the Kentish Rag.

south-eastern side of a little combe we again find the hard white sandstone, capping a spur of the hill, and about three yards below it the softer bed crops out. I have examined microscopically the hard bed, which recalled to my mind, before I had read the passage quoted above, some of the hardest 'greywethers.' It consists almost wholly of fairly angular to subangular quartz grains, commonly about ·0125″ in diameter, which are probably derived from some granitoid rock, but do not exhibit any minor peculiarities worthy of remark. These are cemented by secondary quartz, in no great quantity, which is sometimes, but not always, in perfect optical continuity with the original grains, which often appear enclosed by coloured rings when viewed with crossed Nicols; probably from causes similar to that which produces them in separate grains and chips. There are a few grains showing a minute chalcedonic structure and one or two of brown or nearly black iron oxide. Parts of the slide also have a rather dirty look—in short, the rock is very like one of the hard grits or less perfect quartzites that one finds among the older Palæozoic rocks.

The other rock mentioned above is peculiar. It is of a glaucous green colour, varying somewhat in depth, and it weathers on the outside to a rusty brown. This suggests that the tint is due to a silicate of iron, and in the process of weathering the cementing mineral appears to be partially removed; for the discoloured portion, often an inch or so in depth, is less solid than the rest of the rock. Occasionally a smooth face of a fragment—probably an old divisional surface—has a kind of glazing of the green-coloured substance. The stone probably occurs *in situ* at a slightly higher level in the Folkestone Sands (here about 100 feet thick) than the white rock, for shallow pits have been dug in search of it over the upper part of Oldbury Hill.[1] Boulders also were formerly abundant over the surface in many places, resulting from past denudation. Some also, like erratics, as Mr. Harrison informed me, have been transported northward and eastward for more than a mile, and may be found lying on the lowland of Gault almost as far as the base of the escarpment of the North Downs.[2]

The mode of working for the masses of green rock suggests that, like the Sarsen-stones of the Tertiary and the Cornstones of older rocks, they are of concretionary origin. The rock is not generally seen *in situ*, but Mr. Hale took me to a sandpit where two masses were exposed. The opening was some 20 feet deep. In the lower part the sand was markedly false-bedded, being in the upper fairly horizontal, with alternating coarser and finer bands of white, pale red, or brownish colour. To a depth of perhaps a couple of yards the usual flaggy masses of sand cemented by limonite were common. The two blocks of green 'quartzite' were nearly on the same level,

[1] Mr. Harrison informs me that when the rock was extensively worked for the Metropolitan roads, some half-century since, it always occurred in detached masses, so that the opener of a pit might get sometimes nothing, sometimes a rich return, for his pains.

[2] The surface of the ground at the Camp is from about 500 to 600 feet, of the Gault about 300 feet above the sea.

one being rather less than a foot in thickness, the other perhaps about six inches,[1] and well-defined bands of ironstone extended for a foot or so below them. Beneath them consolidated sand was rare or absent. The relation of these masses to the surrounding sand left no doubt in my mind that they were of concretionary origin; the sand being cemented by deposition of secondary silica.

When examined with the microscope the green rock is found to consist almost entirely of grains of quartz, often about ·02″ or ·025″ diameter, which for the most part are remarkably well rounded. These contain, in variable number, cavities, generally very small and commonly empty, and occasional microlithic enclosures, such as hair-like belonites, brownish-olive films (mica or in some cases tourmaline?), and occasionally zircon. One grain also contains a number of yellowish-brown needles about ·005″ long. The general aspect of these grains leads me to conclude that they have been derived from a granitoid rock. With them occur a few grains of a chert (perhaps not generally so well rounded) varying in colour from brown to colourless, and sometimes apparently containing fragments of organisms. Rounded grains of limonite also occur as is common in the Folkestone Sand. There are also a few fragments distinctly of organic origin, presently to be described. The cementing material is chalcedonic quartz, the tiny crystals commonly growing outwards from each sand-grain, like a fringe, having a moderately distinct radial arrangement. The surfaces of adjacent grains are rarely quite in contact, but even at the nearest parts are separated by a thin

Felix Oswald del.

Ightham Stone × 35.

film of microcrystalline silica. Now and then an interspace between the fringes is occupied by chalcedonic silica, confusedly arranged, or more rarely by limonite, which probably is associated with silica. Occasionally brown films may be noticed in the quartz grains themselves, as though the limonite had made its way into cracks. The

[1] From their position in the scarped face of the sand, they could not be reached for measurement without an amount of trouble that would have been wasted.

lighter varieties of the rock exhibit under the microscope no indication of the colouring matter, except, perhaps, that the boundary of grains appears somewhat more definitely marked than is usual in a colourless quartzite, but in some of the darker specimens a thin greenish-coloured film can be detected round each grain, and the same tint is disseminated through the microcrystalline 'cement.' It would appear then that the first stage of consolidation was the deposit of a film of iron-silicate, minute quantities of which were from time to time precipitated during the formation of the chalcedonic quartz. The figure represents, somewhat diagrammatically, the general structure of the rock, omitting the organisms and darker grains.

The fragmentary organisms contained in this rock are not very common. Those which I have noticed are not much larger than the sand grains, and are often somewhat cylindrical in form. They can be readily detected with a good lens. With the exception of a few which resemble Annelid tubes, but may possibly be inorganic, they are of a pale green colour, and appear to have a slightly roughened surface, one or two much resembling bits of small spines of an Echinid. When seen under the microscope, they exhibit a peculiar reticulate structure, dark in colour, with the interspaces occupied by microcrystalline silica. I have no doubt they are really from an Echinid, some being probably bits of the test, while others are from the spines. One slide gives a very good transverse section of a spine about ·14″ in diameter.[1] I note also a longitudinal section of a moderately elongated spiral Gasteropod, about ·25″ long, with one or two other fragments, of the nature of which I am doubtful.

So far as I am aware this conversion of a sandstone into a quartzite by the deposition of chalcedonic silica is rare among the older rocks. In my own researches I have never come across a case, but Prof. R. D. Irvine mentions its occurrence among the older American quartzites, and figures an example from a cherty Potsdam sandstone from Wisconsin.[2] It occurs also in the 'Sarsen stones' and in the matrix of the Hertfordshire 'Puddingstone,' but in all these cases (so far as I know) the growth of the chalcedonic silica is much less regular than in the rock which I have described. But after I had examined the above described specimens, Miss C. A. Raisin, who at my request had undertaken the investigation of a parcel of rocks from Somali-land, found a very similar case, which will be noticed in the account which she is preparing.

IV.—Age of the Clwydian Caves.

By C. E. De Rance, F.G.S., A.I.C.E.

THE following abstracts of early papers, on the Cefn Caves, throw a most interesting light on the sequence and method of occurrence of the deposits found at the Tremeirchion Caves, which are

[1] I have to thank Dr. G. J. Hinde for specimens for comparison. The genera *Pseudodiadema* and *Peltastes* seem to be most common in the Upper Neocomian rocks of England. So far as I can judge, I should refer these spines to the former genus.

[2] Fifth Annual Report of the U.S. Geol. Survey, plate xxxi.

four miles east-north-east of them, and on the opposite side of the Elwy and Clwyd valley.

In February, 1832, the Rev. Edward Stanley, afterwards Bishop of Norwich,[1] visited the Cefn Cave, and found the bones of animals, stags' horns, and a human skull pierced with some sharp implement; he was then shown a new cave, about 100 feet above the lower one, and about 40 or 50 feet below the summit; it was discovered in cutting new walks on the hill-side constructed by the owner, Edward Lloyd, Esq.; he found the new cave to have two distinct entrances, the western being full of bone-earth made of comminuted fragments of bone, with numerous large bones of animals, crushed apparently by hyænas, whose teeth were found to be numerous. The cave could then be followed a distance of about 80 feet, with a varying height of six to ten feet; the top portion was clear of material, but he considered that the mass of drift formerly "filled up every cranny and fissure to the very roof." From this examination and another made on the 4th of April, he found the beds to consist "of fine loam, or clay of an ochrey colour and calcareous nature, readily effervescing with acids; generally speaking, the mass is deposited in horizontal laminæ, portions of which may be readily detached, but broken in upon, without order or regularity, by pieces of limestone, which, from their position and angular form, have evidently fallen from the roof. Bones were numerous, and broken pieces of hazel or birch occurred."[2] Mr. J. E. Bowman[3] carried his examination 25 feet beyond that of Dr. Stanley; he found the surface of the drift to be 18 inches beneath the roof of "the cavern" (upper cavern of Stanley); he infers from the trough-shaped entrance, and from the presence of sand and gravel in the cavern, that "the cave must have been a watercourse." He found the section to be as follows:—

1. Innumerable laminæ of impalpable mud or silt, alternating reddish (effervescing) bands, and pale ochreous layers that do not effervesce 1′·6″ to 2′·0″.
2. Marl or clay with angular limestone, and water-worn pebbles, with bones and teeth a little way from the top, increasing downwards into a pure bone-earth, containing Hyænas, Rhinoceros, etc., about two feet.
3. Compact "diluvium of clay," with pebbles of clay-slates, and a few splintered bones, and stalactites, two feet.
4. Coarse and fine sand, loam, and clay, no bones, pebbles, or shells, three feet.

Mr. Joshua Trimmer,[4] in 1838, describes in a paper published in full in 1841,[5] the Cefn Cave as occurring at the point in which the erratic gravel of the eastern and northern side of the Cambrian passes into the district overspread with detritus from Cumberland;

[1] Father of Dr. Stanley, Dean of Westminster.

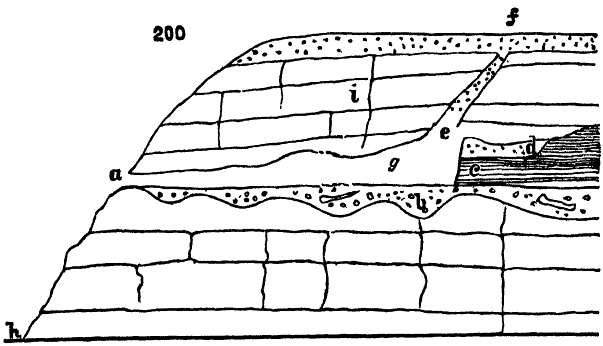
[2] Edinburgh New Phil. Journ. vol. xiv. p. 40–53; Proc. Geol. Soc. London, vol. i. p. 402 (abstract).

[3] J. E. Bowman, Cefn Bone Caves, Brit. Assoc. 1836.

[4] Trimmer, Cefn Bone Caves, Brit. Assoc. Report for 1838, London, 1839.

[5] Practical Geology and Mineralogy, London, John W. Parker, West Strand, 1841, p. 400, etc.

in a gorge of the Elwy, a little above its junction with the Clwyd, its mouth being 100 feet above the river and 200 feet above the sea; the cavern, he states, communicates with the surface by fissures, which, like the surface, are occupied by Northern Drift. Sedimentary deposits containing bones and teeth of Hyæna, Bear, and Rhinoceros, filled the cavern mostly to the roof; these were divided into two beds by a crust of stalagmite; the lower bed, he states, "was below the level of the entrance from the face of the cliff, and contains bones and teeth enveloped in sediment, and mixed with smooth pebbles like those of the adjacent river, and fragments of wood." Above the stalagmite the upper bed consisted of "calcareous loam containing bones and angular fragments of limestone, on the surface of which," he stated, "are sand and marl containing fragments of marine shells like those dispersed over the neighbouring district. The sediment within the cave is generally finely laminated." The author points out that the lower bed must have been derived from the river, when it flowed at a different level; he states that marks of teeth on the bones prove the cave to have been the home of carnivora, and that it was subaerial for some time, allowing the stalagmite to form, and states, that Dr. Traill noticed that the laminæ of the overlying deposit conform to the dip of the limestone, and attributes this also to fluviatile action, subsequent to the marine irruption from above. Mr. Trimmer illustrates his remarks by the following section:



a. Level of the entrance of the cave.
b. Deposit of mud, covered by stalagmite and containing bones, with rounded pebbles of grauwacke and limestone and pieces of wood.
c. Mud, bones, and angular fragments of limestone.
d. Sand and silt, with fragments of marine shells.
e. A fissure communicating with the surface.
f. Northern drift spread over the surface of the country.
g. Portion of the cave cleared of mud.
h. River Elwy, 100 feet below the cave.
i. Limestone rock.

In 1863 the "Geologist"[1] states that bones in the possession of Colonel Watkin Wynn, discovered in the Cefn Cave, were examined and named by Dr. Falconer, and found to belong to

[1] Geologist, vol. vi. p. 114, 1863.

Elephas antiquus, *Rhinoceros hemitœchus*, *Rhinoceros tichorhinus*, *Hippopotamus major*, *Bos* sp., *Cervus* sp., and others, and states that Dr. Falconer and Professor (now Sir Andrew) Ramsay together discovered fragments of Cockles and other marine shells in the clay, and amongst gravel and stones, with which the cave is filled.[1] Sir Andrew Ramsay himself refers[2] to this discovery, and states that the Cefn caves "were below the sea during part of the Glacial Epoch, for the Boulder-clay beds reach a higher level, and with Dr. Falconer I found fragments of marine shells in the cave overlying the detritus that held the bones of elephants and other mammalia."

No reference is made by Dr. Buckland, in the "Reliquiæ Diluvianæ," to the Cefn Cave, but he quotes Pennant as to the discovery of two molar teeth and tusk of Mammoth at Halkin Mine at the mouth of the Vale of Clwyd, which was probably the Talargoch Mine, of which Dr. Buckland gives the following section:—

	Yds.	Ft.
Vegetable mould	0	2
Clay	26	0
Sand and Gravel	68	0

He states that pebbles of lead and some pebbles of copper occurred in the gravel, and that horns, teeth, and bones of Mammals occurred at from 40 to 70 yards from the surface, and also in the bottom bed resting on the subjacent rock.

Mr. Mackintosh[3] found the "sand with minute fragments of sea shells, still adhering to one side, of a rising branch" of the cavern "ascended by steps." On the 22nd of May last Mr. Bouverie Luxmoore, F.G.S., and the writer, found this bed still visible, fragments of *Tellina Balthica* being determinable.

From these observations it is obvious that the bones discovered belonged to Mammals, who lived before the filling up of the Vale of Clwyd, and the sealing of its cavern by Glacial Drift.

V.—Notes on the Igneous Rocks of the Lleyn Promontory.

By J. Vincent Elsden, B.Sc. (Lond.), F.C.S.

MANY of the rocks of this district have been already described by the late Mr. E. B. Tawney, in a series of papers entitled "Woodwardian Laboratory Notes," contributed to the Geological Magazine a few years ago. The following additional remarks are to a certain extent supplemental to the above-mentioned papers, and are founded on a microscopical examination of a large series of rocks, collected some few years ago during a brief visit to the Lleyn district.

Commencing at the extreme end of the promontory, we find around Aberdaron three or four masses of intrusive rock, which are described in Mr. Tawney's paper as diabase, containing plagioclase often full of greenish microlites, augites in small quantity, of corroded outline and much altered into viridite, and a large quantity of black iron-

[1] Dr. Murchison states Dr. Falconer's visit was in August, 1859.
[2] Physical Geology and Geography of Great Britain, p. 462, 5th edition.
[3] Q.J.G.S., 1876.

oxide, both magnetite and ilmenite.[1] His specimens were selected from Pen-y-cil, Aberdaron quarry and Tynrhedyn, S. of Llanfaelrhys, and to his description of these rocks I find nothing to add, with the exception that one of my rocks taken from Pen-y-dre, close to Aberdaron, contains a much larger quantity of augite, in well-defined crystals.

The small isolated patches, lying to the North of Aberdaron, and coloured as serpentine on the Survey map, are not described in Mr. Tawney's paper. I obtained specimens of these so-called serpentines from Hendrefor, Ty-hen and Methlan. The rock from the last-mentioned locality appears under the microscope to consist of a network of plagioclase crystals, sometimes polarising brilliantly, but generally clouded with minute enclosures and decomposition products. The felspars are seen penetrating plates of augite, with brilliant polarisation colours. The whole rock is traversed by veins of serpentinous substance, and there are many patches of viridite. Biotite is sparingly represented and probably of secondary origin. Titaniferous iron, mostly decomposed into leucoxene, is present, and some bronze crystals of pyrite are seen by reflected light. Although there is far more serpentinous and viriditic matter than in the rocks of Aberdaron, iron separation has been less extensive.

The specimen from Ty-hen is finer-grained, and the felspars much more decomposed. The interspaces are chiefly filled with green fibrous viridite, with aggregate polarisation. There is but little fresh augite, and a good deal of titaniferous iron generally altered into grey opaque leucoxene. Some threads of serpentinous substance also occur, and a little secondary biotite. Two specimens taken from the extreme margins of these small bosses are interesting examples of contact metamorphism. The felspar crystals become very minute, probably owing to more rapid consolidation, and portions of the surrounding sedimentary rock appear entangled in a confused way with the igneous matter.

Macroscopically these rocks are greenish-looking and sufficiently soft and serpentinous to account for the Survey colouring. They do not differ much, however, from the diabases around Aberdaron, except in their more pronounced viriditic decomposition.

We come now to the large mass of igneous rock extending from Mynydd Penarfynydd on the south to Mellteyrn on the north. The rocks of this area are especially interesting on account of their variety. Thus the western slopes of the Penarfynydd ridge, as shown by Mr. Tawney, are of olivine diabase, which he considered to be a dyke intrusive in the hornblendic diabase of which the rest of the ridge is composed. It must be mentioned also that Mr. Tawney was unsuccessful in his attempt to discover the locality from which Sedgwick procured his specimen of hornblende picrite in this vicinity. The specimens of hornblende diabase described in "Woodwardian Laboratory Notes" were taken one from Careg Llefain, and the other from near Plas Rhiw.

My first specimen, in connexion with this area, was taken from

[1] Geological Magazine, 1880, Decade II. Vol. VII. p. 214.

the northern flank of Mynydd-y-Graig, about midway between these last-named localities. In this rock plagioclase is abundant, but rather decomposed. The extinction angle is rather large, corresponding to anorthite. Some crystals look like orthoclase twinned on the Carlsbad type, but are shown by their symmetrical extinction of about 33° to the trace of the twinning plane to be plagioclase. The augite is sometimes tolerably fresh, extinguishing perfectly, but other crystals show aggregate polarisation. It is often interpenetrated by felspar, and the margins are developed into strongly dichroic brown hornblende. A brownish granular substance is often arranged in bands across the cleavage directions, and sometimes there are inclusions of hornblende. There is also a good deal of fibrous yellowish green viriditic substance, resulting probably from the decomposition of augite and hornblende. In one case lines of opaque granular decomposition product intersect at the characteristic prism angle of augite.

At Treheli the same general characteristics are noticed. Under the microscope the plagioclase is seen to be abundant, but rather decomposed, Where polarisation colours are still given, the extinctions are apparently not so high as in the last-mentioned specimen. The augite is also not so fresh: it occurs in irregular masses, often developed into hornblende. Some crystals have a central patch of decomposition product, giving aggregate polarisation, the margins extinguishing perfectly. In other cases the margins are decomposed and the centre fresh. Large masses of a clear pale yellow substance, with granular patches here and there, show between crossed Nicols a central dark patch, changing but little on rotation, surrounded by densely interlacing fibrous crystals, with brilliant aggregate polarisation and feebly pleochroic. These fibrous, tufted crystals occur chiefly at the junction of hornblende and augite. The hornblende is much less altered than the augite, many of the viridite patches being fringed by perfectly fresh-looking hornblende. Original magnetite seems scarce, but lines of secondary oxide of iron often mark the boundaries of augite crystals, the interior being occupied by viridite.

North of the road near Tyganol-bwlch-y-rhiw, we begin to approach the so-called Rhos Hirwaun syenite, and here the rock undergoes considerable change in character. The felspar is here very opaque, and often encloses green microliths. The augite seems to be nearly all converted into viridite, which is interpenetrated by the felspars. Even the apparently unaltered fragments give aggregate polarisation. Quartz is fairly abundant in crystals and irregular grains, and generally contains enclosures of apatite needles, as well as cloudy patches of fluid and gas cavities. No hornblende can be detected; but there are a few ill-defined flakes of brown mica. There is a fair quantity of magnetite, and some ilmenite, partly converted into leucoxene. This rock appears to be a quartz-diabase, but a comparison would be interesting with the diabase of Castell Carron, about two miles north of this point, in which Tawney recognized quartz of secondary origin.

Immediately around Meyllteyrn we find the whole rock consisting of a network of felspar prisms, generally rather turbid, the interspaces being filled with augite in every stage of decomposition into viridite. In one specimen not a fragment of unaltered augite remains, while in others some crystals are still very fresh, polarising brilliantly and extinguishing perfectly. One large patch of viridite has at its two extreme ends two small portions of still unaltered augite, which extinguish simultaneously, as if originally portions of one and the same crystal. Magnetite is not very abundant, and generally of secondary origin, forming imperfect skeletons of augite crystals. There is a fair quantity of ilmenite, but much decomposed into leucoxene, and pyrites is sparingly present.

It now remains, before leaving this tract of igneous rock, to mention the so-called Rhos Hirwaun syenite, which is mapped by the Survey as occurring in two isolated patches. It has been shown by Mr. Tawney that the boundaries of these patches are incorrectly mapped, for he describes specimens from Pen-y-gopa and Penllech (within the greenstone area) which should belong to the so-called syenite, while the rock of Clip-y-Cilfinhir is in reality a diabase.[1] The rock of Pen-y-gopa differs from that of Ty-mawr, described by Prof. Bonney,[2] in containing hornblende and but little mica, and is described as hornblendic gneiss. The specimen about to be described is taken from quite the other side of the main mass of this rock, from near Pen-y-bont, close to Llangwnadl. In the hand specimen this rock is an exceedingly tough fine-grained dark green hornblendic rock, traversed by fine veins of lighter green and speckled with small grains of quartz and felspar. Under the microscope the rock is seen to consist chiefly of dark greenish-brown hornblende, with characteristic cleavage and strongly dichroic where fresh, but the dichroism decreases rapidly with alteration, and it ultimately passes into a chloritic pseudomorph. The felspar is generally turbid, but here and there shows the characteristic twinning of plagioclase. Some orthoclase is also recognizable. The quartz is almost indistinguishable from the felspar except in polarised light, and is generally turbid with a multitude of minute cavities. A few crystals of magnetite and some pyrites are present.

On the whole this rock bears a much closer resemblance to the Pen-y-gopa specimen than to that of Ty-mawr, but there seems to be scarcely sufficient trace of foliation to entitle it to be classed as hornblendic gneiss.

Between Llanengan and Llangian are two small greenstone areas not touched in Mr. Tawney's paper. At Pen-y-gaer quite half this rock appears to consist of felspar, but much decomposed. The felspars form a network, filled up by augite, which it also penetrates deeply. The augite is brownish, with much iron separation along the cleavage cracks, and sometimes the whole crystal is rendered opaque from this cause. Scarcely any of the augite extinguishes

[1] Geological Magazine, Vol. X. p. 68.
[2] Q.J.G.S. vol. xxxv. p. 306.

completely between crossed Nicols. There is a good deal of strongly dichroic hornblende, sometimes intergrown with the augite, at other times in detached crystals. It generally polarises more brilliantly and extinguishes more thoroughly than the augite. Viridite patches are abundant, and a little secondary quartz occurs. Most of the iron oxide shows the grey decomposition product of ilmenite, but some pyrites is to be noticed. The same rock near Llangian is much more decomposed, the felspars being quite opaque and much viridite and opaque ferric matter present. Some of the viridite tracks appear to have outlines of augite crystals; one looking like an orthodiagonal section gave an angle of 135°, which nearly corresponds to the angle between ∞ P and ∞ $P^c\infty$ (clinopinacoid) in augite. Small quartz fissures traverse the rock.

We now pass to the large patch coloured as porphyry on the Survey Map, lying between Llanbedrog and Capel Ceidio. The southern portion of this area consists chiefly of quartz-felsite, and at Pig Street, Mr. Tawney described a volcanic ash. I find a coarse tuff on the south side of Mynydd Mynytho, and a similar kind of rock to the north of Madryn, at Y Gledrydd. My other specimens from this area do not differ essentially from those already described in Woodwardian Laboratory Notes.[1]

The Boduan mass of porphyrite is described from several localities in Mr. Tawney's paper. I will only add one more description of a rock taken from the extreme south side, near the village of Boduan. The rock here is much decomposed: the ground-mass is micro-crystalline, consisting of small felspar prisms, which from the small extinction angle is possibly oligoclase. Precise determination of the larger felspars, which occur porphyritically, is difficult owing to decomposition, but no orthoclase can be recognized with certainty. There is some glassy base between the crystals. A few magnetite grains and a good deal of opaque ferric matter occur throughout. No trace of hornblende remains, although a few feebly dichroic chloritic pseudomorphs are to be seen. This rock differs, therefore, from that of Carn Boduan.

Approaching Nevin the character of the rock changes considerably. I give a description of the rock near Nevin, which much resembles that described by Mr. Tawney as probably coming from Moel Gwyn, and which he classes as epidiorite. The large felspars are much decomposed, but are apparently triclinic: they are generally filled with a fine granular substance, and sometimes crowds of colourless microliths are visible with crossed Nicols. The ground-mass consists chiefly of quadrangular sections, with nearly parallel extinction, corresponding to oligoclase. Hornblende is present in detached crystals, which gradually lose their fibrous structure and dichroism and pass into chloritic pseudomorphs. A few remnants of augite are visible. Magnetite is abundantly associated with the decomposing hornblende, and there are some opaque rhombohedral crystal of ilmenite.

[1] Geological Magazine, Vol. X. p. 70.

We now come to the so-called serpentine of Porth Dinlleyn, described by Prof. Bonney in Q.J.G.S. vol. xxxvii. p. 48, and identified as altered diabase-tuffs, decomposed diabases and basalts. His specimens were selected exclusively from the eastern side of the peninsula. I therefore proceed to the west side of the promontory. Near the "Ancient Fortress" the rock appears to be a true diabase, and shows under the microscope a network of felspar, too clouded for determination of extinction angles. Strings of serpentinous matter and a good many viridite patches are scattered through the slide. Pale brownish augite occurs in small crystalline grains still polarising brilliantly. The opaque bodies are not abundant, and seem to consist entirely of magnetite and some pyrites. A little further south the rock is very similar to the above. About half the slide consists of prisms of felspar, sometimes polarising brilliantly, but generally decomposed. The extinctions are at a somewhat high angle to the trace of the twinning plane. Some of the felspars are porphyritic, with broken outlines. Augite is sparingly represented in detached grains and crystals, rather deeply coloured, and showing marked pleochroism. A good deal of greenish decomposition product occurs between the felspar crystals, and magnetite, ilmenite and some pyrites are scattered throughout. Apatite needles and a little biotite also occur here. Some of the felspars show a tendency to to saussuritic decomposition, giving aggregate polarisation, and greenish alteration products with some epidote.

Still further south the rock becomes more serpentinous in appearance, and under the microscope more than half the slide is seen to consist of bright green serpentine, the remainder being an opaque, greyish substance, interpenetrated everywhere by serpentinous matter. Patches of calcite abound, and threads of the same mineral traverse the serpentine. Innumerable bands of dark granular matter, in more or less wavy parallel lines, occur throughout. These under higher powers transmit feeble brownish colours, and have the appearance of picotite. This is so far as I know the only instance of the occurrence of a rock approaching the character of true serpentine in Lleyn. The arrangement of the opaque bands is not such as to recall the "maschen structur" of peridotic serpentines, but possibly as my specimen was taken from the junction of the rock, we may have here the results of contact metamorphism of the surrounding schists.

The greenstone dykes of Porth-wen appear to be chiefly dolerite, Under the microscope the rock appears to be crowded with lath-shaped crystals of felspar, no longer polarising in very bright colours. A good deal of viridite and some biotite are present. Olivine crystals are almost entirely altered, but are still recognizable. Augite also remains, but generally very opaque, from iron separation. A good deal of secondary calcite is seen, as well as magnetite and pyrites.

VI.—Note on the Classification of the Ichthyopterygia (with a Notice of Two New Species).

By R. Lydekker, B.A., F.G.S., etc.

HAVING devoted several weeks to the study of the magnificent collection of the remains of Ichthyopterygians preserved in the British Museum (Natural History), I purpose on this occasion to give a brief notice of some of the conclusions at which I have arrived, since a considerable interval will elapse before the publication of that part of the Museum "Catalogue of Fossil Reptilia" in which my observations will be more fully recorded.

Exclusive of the genus *Cetarthrosaurus*, which is referred by Mr. Hulke to the *Mosasauridæ*, four genera of Ichthyopterygia have hitherto been described; viz. *Ophthalmosaurus*, Seeley, *Baptanodon* (*Sauranodon*), Marsh, *Ichthyosaurus*, König, and *Mixosaurus*, Baur. Since, however, there appear to be no characters by which *Baptanodon* can be generically separated from *Ophthalmosaurus*, I am inclined to follow the suggestion made by Dr. Baur, and unite the two; thus reducing the number of genera to three. With regard to *Ichthyosaurus*, it has been suggested by more than one writer that this genus is susceptible of division into two or more genera; and there is much to be said for this view, since there is an extraordinary amount of structural difference between many of the forms. If, however, the species be arranged in their natural relationship, which corresponds to a great extent with their distribution in time, it will be found that these distinctive characters tend to shade more or less completely into one another. Since, moreover, the skulls of all the species seem to be so nearly alike in general structure that it is very improbable that good generic characters could be drawn from them, I have come to the conclusion that it will be more convenient to the palæontologist, and most certainly to the pure geologist, to retain the genus in its original wide sense. I intentionally use the term convenient in this conjunction because I am glad to see that Prof. Flower,[1] in his recently published memoir on the Liberian *Hippopotamus*, has expressed his opinion very clearly that the restriction or multiplication of generic terms is purely and simply a matter of convenience; and that their multiplication rather tends to make us lose sight of the mutual relationship of allied forms. I am further convinced of the advisability of retaining the original use of the term *Ichthyosaurus*, because if we once begin to subdivide it, it will be almost impossible to know where to stop.

Dr. Baur, who adopts the view of the advisability of splitting up the type genus, makes the three above-mentioned genera the types of three distinct families; but if the term *Ichthyosaurus* be employed in the sense indicated above, it appears to me that the whole three genera may be conveniently included in a single family—the *Ichthyosauridæ*.

The last-mentioned writer has shown very clearly that while *Ichthyosaurus* occupies the middle position, *Ophthalmosaurus* is the

[1] P.Z.S. 1887, p. 614.

most, and *Mixosaurus* the least, specialized genus; and I find that while among the Liassic species *Ichthyosaurus communis* in the structure of its limbs makes the nearest approach to *Ophthalmosaurus*, *I. tenuirostris* and its allies are the forms most nearly allied to *Mixosaurus*. Now the pectoral limb of the generalized *I. tenuirostris* having only four digits, while in the more specialized species the number is greatly increased, it may be inferred that Ichthyosaurs have descended from a tetradactylate ancestor, or at least that only four digits have been primarily modified into the Ichthyosaurian paddle. A comparison of the pectoral limb of *I. tenuirostris* with that of *Chelydra* has moreover led me to conclude that the four digits there found correspond to the 2nd, 3rd, 4th, and 5th of the typical manus; the 3rd arising in the same way from the intermedium, and the 4th and 5th conjointly from the ulnare. The primary grouping of the genus which I have adopted is mainly based upon the simpler or more complex structure of the pectoral limb; and I may add that in those forms where the original four digits have become split up it is evident that the presence of two centralia in the carpus is an acquired and not an inherited character. This classification is in the main a modification of the one proposed by A. Wagner, and subsequently extended by Col. Kiprijanoff in the Memoirs of the St. Petersburg Academy for 1881. It is briefly summarized in the following table, which contains a synopsis of all the named species with which I am acquainted. The specific names applied by Hawkins to several of the English Liassic species are, however, omitted. In cases where the generic position of species is uncertain a note of interrogation is placed after the generic name; and when the serial position is provisional an asterisk is prefixed:—

I. Genus OPHTHALMOSAURUS, Seeley (*Baptanodon* = *Sauranodon*, Marsh).—Humerus articulating distally with three bones.

1. OPHTHALMOSAURUS ICENICUS, Seeley. Oxford and Kimeridge Clays, England.
2. OPHTHALMOSAURUS NATANS (Marsh). Up. Jurassic, N. America.
3. „ DISCUS (Marsh). „ „ „
4. „ CANTABRIGIENSIS, n.sp. *nobis*. Cambridge, Greensand.

II. Genus ICHTHYOSAURUS, König.—Humerus articulating distally with only the radius and ulna, which are short and in close apposition.

A. Latipinnate Group.—Pectoral limb with the third digit (that arising from the intermedium) containing two longitudinal rows of bones and two centralia; radius very short, with entire anterior border.

a. Campylodont subgroup.—Roots of the teeth enveloped in cement; humerus with prominent trochanteric ridge.

α. Femur very short, with trochanteric ridge enormously developed.

5. ICHTHYOSAURUS CAMPYLODON, Carter. Up. Cretaceous, Europe.
*6. „ INDICUS, *nobis*. Up. Cretaceous, S. India.
*7. „ STROMBECKI, Meyer. Neocomian, N. Germany.
*8. „ POLYPTYCHODON, Koken. Neocomian, North Germany.

β. Femur longer, with trochanteric ridge less developed.

*9. ICHTHYOSAURUS (?) OVALIS, Phillips. Kimeridge Clay, Eng.

*10. „ (?) THYREOSPONDYLUS, Phillips. Kimeridge Clay, England.

Syn. (?) *I. brachyspondylus*, Owen.
(?) *I. thyreospondylus*, Owen.

11. ICHTHYOSAURUS LEPTOSPONDYLUS, Wagner. Kimeridgian, Bavaria.

12. ICHTHYOSAURUS ENTHECIODON, Hulke. Kimeridge Clay, England.

13. ICHTHYOSAURUS TRIGONUS, Owen. Kimeridge and Oxford Clays, England.

Syn. (?) *I. posthumus*, Wagner. Kimeridgian, Bavaria.

*14. ICHTHYOSAURUS (?) DILATATUS, Phillips. Kimeridge and Oxford Clays, England.

*15. ICHTHYOSAURUS HILDESIENSIS, Koken. Neocomian, North Germany.

b. Typical subgroup.—Roots of the teeth without cement; humerus without prominent trochanteric ridge.

16. ICHTHYOSAURUS COMMUNIS, Conybeare. Low. Lias, England.

17. „ BREVICEPS, Owen. „ „

18. „ CONYBEARI, n.sp., *nobis*. „ „

19. „ INTERMEDIUS, Conybeare. „ „

B.—Longipinnate Group.—Pectoral limb with the third digit containing one longitudinal row of bones and a single centrale; radius nearly square, and usually with notched anterior border.

a. Acutirostrine subgroup.—Teeth small and cylindrical, coracoid without posterior notch; head of humerus oblong.

20. ICHTHYOSAURUS INTEGER, Bronn. Up. Lias, Würtemberg and (?) England.

21. ICHTHYOSAURUS ACUTIROSTRIS, Owen. Up. Lias, Europe.

Syn. *I. longipennis*, Mantell.
I. microdon, Wagner.
I. quadriscissus, Quenstedt.
I. Zetlandicus, Seeley.
I. longifrons, Owen.

b.—Tenuirostrine subgroup.—Teeth small and cylindrical; coracoid with posterior notch; head of humerus triangular.

22. ICHTHYOSAURUS TENUIROSTRIS, Conybeare. Lias, Europe.

Syn. *I. grandipes*, Sharpe.

23. ICHTHYOSAURUS LATIFRONS, König. Lias, England.

Syn. *I. longirostris*, Owen.
(?) *I. longirostris*, Jäger.

c. Platyodont subgroup.—Teeth large, either cylindrical or carinated; coracoid without posterior notch; head of humerus triangular.

24. ICHTHYOSAURUS LONCHIODON, Owen. Low. Lias, England.

25. „ „ PLATYODON, Conybeare. Low. Lias, England.

Syn. *Ichthyosaurus giganteus*, Leach.

26. ICHTHYOSAURUS TRIGONODON, Theodori. Up. Lias, Bavaria.

III. Genus MIXOSAURUS, Baur. Humerus articulating with the radius and ulna, which are elongated and separated by an interval.

27. MIXOSAURUS CORNALIANUS (Basani). Up. Lias, Italy.
Syn. *Ichthyosaurus cornalianus*, Basani.

The forms indicated by the under-mentioned names cannot be classified, and it is probable that several of them are synonyms of those already mentioned.

28. *Ichthyosaurus æqualis*, Phillips. Kimeridge Clay, England.
29. „ „ *angustidens*, Seeley. Up. Chalk, England.
30. „ „ (?) *atavus*, Quenstedt. Mid Trias, Germany.
31. „ „ *australis*, Hector. (?) Trias, New Zealand. (?) = *Mixosaurus*.
32. „ „ *calorodirus*, Seeley. Kimeridge Clay, England.
33. „ „ (?) *carinatus*, Sauvage. Up. Trias, France. ? = *Mixosaurus*.
34. „ „ *coniformis*, Harlan. ? Lias.
35. „ „ *crassicostatus*, Theodori. Up. Lias, Bavaria.
36. „ „ *gaudensis*, Hulke. Reputed Miocene, Malta.
37. „ „ *hexagonus*, Theodori. Up. Lias, Bavaria.
38. „ „ *hygrodirus*, Seeley. Kimeridge Clay, England.
39. „ „ *ingens*, Theodori. Up. Lias, Bavaria.
40. „ „ *macrophthalmus*, Theodori. Up. Lias, Bavaria.
41. „ „ *megalodirus*, Seeley. Oxford Clay, England.
42. „ „ *Nordenskiöldi*, Hulke. Trias (?), Spitzbergen.
43. „ „ *planartus*, Theodori. Up. Lias, Bavaria.
44. „ „ *polaris*, Hulke. Trias (?), Spitzbergen.
45. „ „ (?) *rheticus*, Sauvage. Up. Trias, France. (?) = *Mixosaurus*.
46. „ „ *triscissus*, Quenstedt. Up. Lias, Würtemberg.

The name *I. latimanus*, as will be noticed below, must be discarded. The names *I. Bonneyi*, *I. Doughtyi*, and *I. platymerus*, Seeley, and *I. advenus*, Phillips, are merely MS. ones; the first three being applied to specimens from the Cambridge Greensand, and the fourth to vertebræ from the Stonesfield slate. *I. Walkeri*, Seeley, has been made the type of *Cetarthrosaurus*.

In regard to the two new species above mentioned *Ophthalmosaurus cantabrigiensis* is founded on a small humerus from the Cambridge Greensand in the British Museum (No. 43989), which differs from that of *O. icenicus* in having the three distal facets of nearly equal dimensions. The name *Ichthyosaurus Conybeari* is applied to an imperfect skeleton of a small Ichthyosaur in the same collection (No. 38523) from the Lower Lias of Lyme-Regis, which differs from *I. communis* in the notching of the anterior border of some of the phalangeals of the pectoral limb, and in the relatively longer skull; while it is distinguished from *I. intermedius* by the greater width of the pelvic limb. It is possible that *I. latimanus*, Owen, may be

identical with this form, but since, as I shall show on a subsequent occasion, that species appears to have been founded by mixing up the characters of two specimens, which are apparently specifically distinct, the name must be abolished.

It is not improbable that one or more of the Kimeridgian species mentioned in the Campylodont subgroup may be referable to *Ophthalmosaurus*, and I think there is considerable probability of this being the case with *Ichthyosaurus* (?) *ovalis*, in which the contour of the vertebræ differs considerably from that obtaining in Kimeridgian species undoubtedly belonging to *Ichthyosaurus*. It may therefore prove that *Ophthalmosaurus icenicus* is even specifically identical with this form. In respect of other species, I have great doubt whether *I. entheciodon* is distinct from the continental *I. leptospondylus* of the same geological horizon, but since I cannot certainly say that the two are identical, it is preferable to allow both names to stand for the present. I find by a comparison of the type skulls of the so-called *I. Zetlandicus*[1] of the Upper Lias of Whitby, and *I. longifrons* of that of Normandy, that these two are evidently closely allied forms; and since certain differences in the arrangement of the bones of the quadratic region do not appear to me to be, at the most, of more than racial importance, I am inclined to refer both forms to a single species. A comparison of the pectoral limb of the Normandy form with that of the Whitby *I. acutirostris* shows, moreover, that both are of the same structural type; and since other Upper Liassic skulls from Whitby, which are indistinguishable from the type of *I. Zetlandicus*, agree equally closely with that of the former, I am disposed to unite both *I. Zetlandicus* and *I. longifrons* with *I. acutirostris*. I find, moreover, that skeletons from the Upper Lias of Würtemberg in the Museum, which agree with the one figured by Renevier in the "Bull. Soc. Vaudois" for 1885 as *I. quadriscissus*, Quenstedt, and also with those from the same region figured by Prof. Seeley in the "British Association Report" for 1880, without specific determination, present all the characters of the present species. And I am confirmed in this conclusion by finding it stated by Theodori in his Monograph of *I. trigonodon* that *I. acutirostris* is the most common form found in the Upper Lias of Bavaria and Würtemberg. The sketch of a skull from the Upper Lias of Banz, in Bavaria, made by Theodori and presented by him to Sir R. Owen, which is preserved in the British Museum, also affords important evidence in this direction, since it shows that the premaxilla and lachrymal did not unite below the nares to exclude the maxilla from that aperture;—a feature which is characteristic of the skulls described as *I. Zetlandicus* and *I. longifrons*.

I may observe also that, as Mr. W. Davies first pointed out to me, *I. longirostris*, Owen, appears to be identical with *I. latifrons*, König. The former name was, however, originally applied by Jäger

[1] I am glad to take this opportunity of thanking Prof. T. McKenny Hughes, of Cambridge, for his courtesy in permitting the type skull of *I. Zetlandicus* to be sent to the British Museum for comparison.

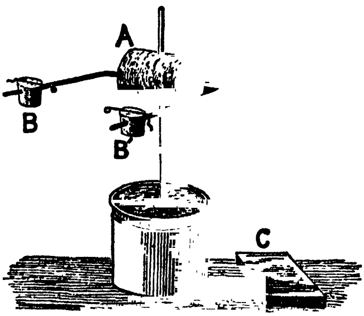
to specimens from the Upper Lias of Würtemberg which are probably also specifically the same.

In conclusion it will be interesting to draw attention to a pectoral limb of *I. acutirostris* (*quadriscissus*), figured by Dr. O. Fraas in the Jahresh. Ver. Nat. Württ., 1888, pl. vii., in which the contour of the integument is perceived. It appears from this figure that the integuments were produced a considerable distance on the posterior border of the paddle so as to form a large fold in the axillary region.

VII.—On Simple Apparatus for Use in the Observation of Flame-Reactions.

By Grenville A. J. Cole, F.G.S.

GEOLOGISTS, who are again and again forced to deal with the most minute or fragmentary specimens, and who find it impossible to cultivate, during their surveys of the earth, the methods perfected by the mineralogist in his learned leisure, have fully recognized the importance of Prof. Szabó's tabulation of the flame-reactions of the felspars. Since the accuracy of the results obtainable depends largely upon the position of the mineral-particle in the flame, I venture to call attention to a form of support that has proved in practice as convenient and efficient as it is simple.



Following a long way in the wake of Prof. Miller's ingenious goniometer, the materials of this little instrument are essentially wire and cork. A small gallipot, such as is used for Liebig's extract, forms a base that is clean, strong, and adequately heavy. A brass wire, about 5 mm. in diameter, passes through the cork of this, and rises 15 centimetres above it, carrying a stout cork A, which can be slid up and down to any level. A steel wire or knitting-needle, some 25 cm. long, is pushed horizontally through A, the last 7 cm. on either side being then bent forward at right angles. Two small corks, B and B′, are carried by the parallel arms thus formed, and support, by means of a knife-slit in the top of each, the fine platinum wires employed. B can be slipped off the steel wire, the mineral fragment can be attached, with Prof. Szabó's precautions, to the platinum loop, and the carrier replaced without fear of loss by jarring. B′ can be used for a type-specimen to be compared with that under examination, the wires on both corks being

adjusted to exactly the same level, and one or other being brought at will into the flame.

The cork A being set approximately at the proper height, the rotation of the steel wire within it moves B and B′ equally in vertical planes, and gives a delicate means of fine adjustment. To secure uniformity of position in successive experiments, the platinum loop carrying the specimen is brought, in the first trial, to the exact level of the top of the bunsen burner, or, in the second and third trials, to the level of the top of the iron cone. A small plate of wood, C, of the thickness of 5 mm., is then slid under the gallipot, the specimen being thus raised to the position adopted by Prof. Szabó, without any of the difficulties that so often arise from the jarring or stiffness of motion in more elaborate supports.

The dimensions above given are those adapted to a bunsen burner of ordinary height and ordinary diameter of base. For packing, the erection can be taken down, and the 5-millimetre plate and the smaller corks can be kept inside the gallipot till required.

This obvious and simple contrivance, with its smoothness and uniformity of adjustment, may possibly facilitate to some busy geologist the practice of the method of flame-reactions; and a sense of the value, not to say the charm, of the observations of Prof. Szabó must be my excuse for thus describing it at length.

VIII.—Note on a Species of *Scymnus* from the Upper Tertiary Formation of New Zealand.

By James W. Davis, F.G.S.

In a Memoir recently published "On the Fossil Fish Remains of the Tertiary and Cretaceo-Tertiary Formations of New Zealand" (Transactions of the Royal Dublin Society, vol. iv. ser. II. p. 11, pl. vi. fig. 22) there is described a small tooth as an immature example of *Carcharodon angustidens*, Ag. The specimen was included amongst a large number of others forwarded for examination by Sir James Hector, Director-General of the Geological Survey of New Zealand; it is a small tooth, exquisitely preserved, and does not exhibit any signs of abrasion by use, which led to its being provisionally considered as the tooth of a young shark, and its form and minutely serrated margin appeared to indicate that its relationship was with *Carcharodon*. I am indebted to Mr. A. Smith Woodward for the suggestion that the tooth belongs to one of the Spinacidæ; a re-examination has convinced me of the correctness of this suggestion, and that it is an example of the genus *Scymnus*, to which genus I have no hesitation in transferring it. The occurrence of this specimen in the Napier series of the Esk River is interesting from the fact that the only existing species, *Scymnus lichia*, is found inhabiting the Mediterranean Sea, and that part of the Atlantic immediately adjoining. The genus is represented in the Miocene Molasse of Baltringen by *Scymnus triangulus*, Probst, a small thin tooth, with a triangular crown and a more or less rectangular base divided into two parts by a vertical slit; from the Pliocene of Tuscany

and the Bruxellian of Woluwe St. Lambert. The New Zealand species may be distinguished from this one by its larger size, more acuminate apex, and by a slight lateral projection from the base of the crown. The Napier series, from which it was obtained, occupies a much higher horizon than the Baltringen Molasse; by the Survey they are considered to be the Upper beds of the Pliocene, whilst Professor Hutton tabulates them as Pleistocene. They underlie the dispersed gravels and peat mosses, the latter containing the bones of the recently extinct Moa. Though the existence of *Scymnus* is unknown in the southern seas, its fossil remains in these beds indicate that its extinction has happened during comparatively recent times. It is desirable that the species should be distinguished, and I suggest as the *nomen triviale, Scymnus acutus.*

REFERENCES TO SPECIES PREVIOUSLY DESCRIBED.

Scymnus triangularis. J. Probst. Würth. Jahresb. v. xxxv. p. 175, pl. iii. figs. 35, 36 (1879). Molasse, Baltringen, Wurtemberg.

S. majori. R. Lawley. Nuovi Studi sopra ai Pesci, etc., p. 38, pl. i. fig. 17 (1876). Pliocene, Tuscany.

S. trituratus. J. Probst. Würth. Jahresb. v. xxxv. p. 176 (1879).

F. Noetling. Sitzb. Ges. Naturf. Freunde Berlin, 1886, p. 17 = *Corax trituratus.*

T. C. Winkler. Archiv. Mus. Teyler, v. iv. fasc. i. p. 27, pl. ii. fig. 13 (1874). Bruxellian, Woluwe St. Lambert, near Brussels.

CHEVINEDGE, HALIFAX.

NOTICES OF MEMOIRS.

I.—PALÆONTOLOGICAL CONTRIBUTIONS TO SELACHIAN MORPHOLOGY.[1] By A. SMITH WOODWARD, F.Z.S., F.G.S.

THE author discussed two features in Selachian anatomy presented by fossils from the Chalk of Mount Lebanon. An examination of the so-called *Scyllium Sahel-Almæ,* which is certainly a member of the Scylliidæ, shows that the lateral line of this fish was supported by a series of half-rings, exactly like those met with in *Squaloraja* and the Chimæroids—a character apparently hitherto unrecognized among undoubted Selachii. The canal of the lateral line in the Cretaceous fossil was thus presumably an open groove; and only two living Sharks, *Echinorhinus* and *Chlamydoselachus,* both comparatively primitive, have yet been described as exhibiting such a condition. The second discussion related to the pelvic cartilage of *Cyclobatis,* one of the Trygonidæ. It had long been recognized that the pair of anterior processes were the homologues of the so-called "prepubics," and the author now attempted to show that the large bent, lateral processes were dorsally placed, and might thus be regarded as "iliac." It seems not improbable that the reflexed distal extremities of the latter originally supported the metapterygia of the pectoral fins, in the same manner as the propterygia were connected with the antorbital (post-palatine) cartilages.

[1] Proceedings of Zoological Society of London, Feb. 21, 1888.

II.—Unterdevonische Crinoiden. Von Dr. Otto Follmann. Verh. d. nat. Ver. Jahrg. xxxiv. 5 Folge, IV. Bd. pp. 113–138, pls. ii. iii.

THIS paper gives detailed descriptions of a numerous suite of Crinoids collected by Herr B. Stürtz from the Lower Devonian strata of Bundenbach and Gemünden. These fossils are mostly in a pyritized condition, but they have been treated by the same methods which proved so successful with the Asteroidea from the same beds, and many new structural features have been brought to light. The following new species are described and figured:—*Triacrinus elongatus*, *Calycanthocrinus* (n. g.) *decadactylus*, *Taxocrinus Stuertzii*, *T. Grebei*, *Codiacrinus Schultzei*, *Ctenocrinus acicularis*, *C. stellifer*, and *C. rhenanus*. Additional details are likewise given of twelve other species previously described from the same geological horizon.

III.—Discovery of *Elephas primigenius* associated with Flint Implements at Southall. By J. Allen Brown, F.G.S., Geologists' Association, 6th May.

DURING last year some important drainage works were carried out at Southall, and sections were exposed in Windmill Lane, a road running from Greenford, through part of Hanwell, across the Great Western Railway to Woodlake, skirting Osterley Park, as well as in Norwood Lane, leading from Windmill Lane, south-westward.

The remains of the Mammoth were discovered in Norwood Lane, about 550 yards from its junction with Windmill Lane, and at the 88 foot contour. They were embedded in sandy loam, underlying evenly stratified sandy gravel, with a thin deposit of brick-earth about a foot in thickness, surmounting the gravel—in all about 13 feet of river drift above the fossils.

The labourers described the tusks as being found curving across the "shore" or excavation, attached to the skull, parts of which, with the leg-bones, etc., and teeth were exhumed. Other bones were exposed in the side of the cutting.

It is probable that the whole of the remains might have been obtained if they could have been carefully exhumed, and if means had been at hand to remove them, as they were in a soft pulpy condition.

The author obtained many of the bones in a fragmentary state, including parts of the fore limbs and jaw, and portions of the tusks, as well as two of the teeth, which were much better preserved; a third molar was found, but broken to pieces by the labourers. Although many of the bones were when gelatinized too much broken to admit of determination with certainty, they were quite unrolled and the joints and articulations of the leg bones and the teeth were unabraded. There can hardly be a doubt that the bones of the whole of the fore part of the Elephant, if not of the entire skeleton, were in juxtaposition.

Several flint implements were found in Norwood Lane in close

proximity to the remains, and a well-formed spear-head nearly five inches in length, of exactly the same shape as the spear-heads of obsidian until recently in use among the natives of the Admiralty Islands and other savages, was discovered in actual contact with the bones. Smaller spear-head flakes less symmetrically worked were also found at this spot. They are formed for easy insertion into the shafts by thinning out the butt end, similar to those found abundantly by the author at the workshop floor, Acton, and described by him in his lately published work, "Palæolithic Man in N.W. Middlesex." Among the implements found here is an unusually fine specimen of the St. Acheul or pointed type, 8 inches long, of rich ochreous colour and unabraded, and a well-formed lustrous thick oval implement pointed at one extremity, rounded at the other, and also unrolled.

From the adjacent excavations in the Windmill Road several good specimens of Palæolithic work were also obtained, including two dagger implements with heavy unworked butts and incurved sides converging to a long point; these were evidently intended to be used in the hand without hafting. Also a form of instrument characteristic of the older river drift, convex on one side and slightly concave on the other near the point and partly worked at the butt; with these were two rude choppers or axes, two points of implements with old surfaces of fracture, and several flakes. It is remarkable that almost all the principal types of flint implements found in the oldest drift deposits are represented in the collection found in the vicinity of the remains of the Elephant. Mr. J. Allen Brown accounts for the deposit of the remains of the Mammoth and associated human relics at this locality by the fact that the underlying Eocene bed rises to within two or three feet of the surface a few yards west of the spot where the bones and implements were found, while towards the Uxbridge Road and upper part of Windmill Lane, the drift deposits thicken, until at no great distance they have a thickness of 14 to 17 feet. Thus the river-drift rapidly thins out and the upward slope of the London Clay reaches nearly to the surface at about the 90th foot contour, and as the level at which the fossils were found (13 feet from the surface) would represent the extent of the erosion and infilling of the valley which had then taken place, it is probable that the higher ground formed by the up-slope of the London Clay then formed the banks of the ancient river, or if another thick bed of drift should be found still further west, in a depression of the Tertiary bed, such as often occurs. The intervening higher ground would form a small island in the stream, in either case a habitual land surface would be formed, with shallow tranquil waters near the banks, not impinged upon by the currents which subsequently set in this direction as shown by the deposit of coarse stratified gravel above the loamy bed and remains.

The author is thus led to the conclusion that the carcase of the Elephant either drifted into the shallow water near the bank, or else, which seems more probable from the presence of so many

weapons near the spot, including the spear-head, found with the remains, that the animal was pursued into the shallow water by the Palæolithic hunters and there became "bogged." Whatever hypothesis may be accepted, there is no evidence of any greater flood or inundation than would often occur under the severe climatic conditions which prevailed during the long period which intervened between the formation of the higher benches of river drift and that of the mid-terrace, only 25 to 30 feet above the present river, in which the remains of the Mammoth and the extinct Quaternary mammalia are more frequently met with under similar conditions. Nor does there appear to be any more reason for ascribing the extinction of the great Quaternary pachyderms to a sudden catastrophe or cataclysm than there is for the extinction of some other Pleistocene forms, such as the Great Irish Deer; while the difficulty involved in this hypothesis is still further increased by the fact that other animals, such as the Reindeer and Musk-sheep of northern habit, as well as southern forms like the Hippopotamus, were not utterly destroyed with their contemporaries by the same cause, but merely migrated to regions more suited to them, as the climatic and other conditions of this country changed.

REVIEWS.

I.—Introductory Text Book of Geology. By David Page, LL.D., F.G.S. Revised and in great part rewritten by Charles Lapworth, LL.D., F.G.S. Twelfth and enlarged edition. 8vo. pp. 309. (London and Edinburgh, Blackwood & Sons, 1888.)

THE publishers of this work are fortunate in having secured Prof. Lapworth's services in bringing out a new edition of it. While careful to retain the arrangement of the original, and whatever was valuable of its matter, the editor has been bold enough to sweep away all that is cumbrous or obsolete, and sufficiently painstaking to rewrite whole chapters in order to bring them abreast of modern geological thought. The result is that he has produced a book which from its simplicity and clearness will be useful for schools, while the introduction of specific names, the careful attention paid to the derivation and meaning of terms, the alternative tables and fresh points of view brought into the "Recapitulations," the real glimpse (not a mere catalogue) of foreign strata, and the new classification of animals and plants, will restore it to its place as an examination text-book. But beyond and above this, the sections on Petrological geology, on the older Palæozoic or Proterozoic rocks, and last but far from least, those on the Igneous and Metamorphic rocks, are well worthy the attention of specialists in these lines of research. That the improvements are wide-spread as well as concentrated we see from the fact that this edition contains more than 70 additional pages and 50 new illustrations. Many of the old artificial-looking sections are replaced by real ones (like the effective drawing of rock strikes in p. 62 and the map and sections on p. 63) and some of the

old fossils are removed and their places taken by others of more value in the present state of science. Professor Nicholson has lent some of the beautiful drawings from his Palæontology, such as *Mosasaurus, Dicynodon, Hesperornis,* and *Odontopteryx* (whose *artificial* teeth, as a lady student once called them, are well shown), and some of the older pictures like the rather *blasé Pterygotus* of p. 186 look poor beside these modern rivals.

In the short sketch of the objects and scope of geology enough elementary knowledge is imparted to enable the student to follow the succeeding chapter on dynamical agencies modifying the earth's crust; but a great deal of space is saved in this section to be used later on more purely geological matters, the author rightly thinking that much of this will have been taught as Physiography; we may illustrate the thoroughness and conciseness of this part by a single sentence on the formation and maintenance of waterfalls. "Where a hard stratum rests upon one of a softer nature, erosion is arrested above and behind, while it goes on unchecked in front and below." The Petrological division is almost too brief, but we notice some good illustrations and oblique and inosculating (loop) faults are defined.

The Historical Geology of the work is not only thorough, but exceedingly interesting, for the author has the faculty of grasping the general facies of a system and presenting it to his readers as a whole, so that he not only gives type sections and descriptions of the fauna and flora, but in a few graphic touches notes their variations in our own limited area and over the rest of the world. In order to this he does not fetter himself by any single literal plan, but moulds his plan to his subject (this is seen in other chapters), and so presents some systems differently from others. The Archæan chapter is an interesting one, and the author's views may be gleaned from this passage:—"As most of the foliated Archæan rocks occur in areas of regional metamorphism, it may be regarded as tolerably certain that they owe their schistose characters to the same agency, and that we are not dealing in a series of such foliated rocks with rock systems, but with petrological complexes." There is a curious passage on page 150, and one can imagine that the author felt a little tempted to add to his list the Dimetian, Arvonian, Lewisian, and Monian systems with their synonymous localities. It is, of course, needless to say that the hand of the master is clearly traceable through the Cambrian, Silurian, and Ordovician sections, and in the latter he has again raised the Shropshire standard for comparison. The palæontology of each system is gone into in detail, repeated stress being laid on the introduction, modification, and extinction of species; its volcanic energy is described, and space is generally found for an account of the economics and scenery of the rocks and of the phases of Physical Geography to which each is due. Liberal space is allotted to the Carboniferous system, which is used as an illustration of the method of working out a system of rocks in its entirety. But we have not time to deal with each system in detail; the advantages of the method of treatment, the amount of matter introduced, its

reliability, and the attractive manner of its setting forth, will be best appreciated by the readers and students for whom the book is meant. We have purposely delayed to speak of the chapters on Igneous and Metamorphic rocks, as these chapters will be the ones to attract most attention. Both are treated from the point of view of the structural geologist, but one who is well acquainted with the minuter and microscopic characters of the rocks he speaks of. The classification of Igneous rocks adopted has a chemical and mineralogical basis, the minuter subdivisions being effected by differences in origin and texture. A notable passage suggests, "It is far more probable, however, that they (granitic bosses) are really laccolites or intrusive sheets upon a gigantic scale, the plane of intrusion and separation, instead of being confined to a single bedding-plane, crossing the bedding of the rocks of the district more or less irregularly and obliquely."

Fig. 53.

Fig. 54.

Fig. 55.

Fig. 56.

Figures illustrating the structures of the Schistose Rocks.

Figs. 53, 54. Macro-structures. Fig. 53. *Flaser gneiss* (*Flaser structure*), natural size. Fig. 54. *Augen-granulite* (*Augen structure*), natural size.

Figs. 55, 56. Micro-structures. Fig. 55. *Mylonite* (*Mylonitic structure*), highly magnified. Fig. 56. *Mica schist* (*Granulitic structure*), highly magnified.

The metamorphic chapter derives great interest from the Survey paper read at the Geological Society a month ago, in which all Prof. Lapworth's conclusions in the Highlands were confirmed. The terms

Hydro-, Pyro-, and Dynamo-Metamorphism are used; the first stages of their action producing altered, but the higher stages metamorphic rocks. Schists are defined as foliated, crystalline rocks, in which the "folia are not in parallel sheets but thin lenticular plates, each plate thickening in the middle," etc. We have next descriptions of *Augen structure*, *flaser structure* (formed of lenticles or ellipsoidal patches or *phacoids* in a fine base), *granulitic* and *mylonitic* structures, the latter being defined as "Compact slaty-looking rocks, composed of material ground to powder, or rock flour, between the great moving masses in the over-faults of that region, like corn between a pair of millstones." The author takes the responsibility of such of these terms as are due to him, and whatever may be the fate of the terms, the origin of the structures as made out in the Highlands seems to be almost undisputed. By Messrs. Blackwood's kindness we are enabled to reproduce the figures which accompany these descriptions.

Then follows an account of the two main sets of opinions on the origin of these rocks, leading to a description of the Highland section. The picture of this is almost an exact copy of Murchison's, teaching us that to the mere drawing of sections must now be added the skilled interpretation of them. We then have a highly condensed, but very valuable account of the *Deformation Theory of Metamorphism* which we print in full:—

"Founded upon the conclusions drawn from all these discoveries, a new theory of the cause of the association and of the varied petrological characters of the rocks in a district of regional metamorphism is being gradually developed at the present time—a theory most closely related to the original suggestions of Darwin, Scrope, and Sharpe. According to these new views, the rocks in such a district do not necessarily belong to any one distinctive geological period, but may be of various geological ages, owing their present association to the effects of lateral pressure, which has more or less obscured the evidences of their original relationships. Some metamorphic areas may possibly be wholly Archæan; others may be composed of patches originally either Archæan, post-Archæan, plutonic, sedimentary, or volcanic. The present structures of the rocks in various parts of such an area may be either original or secondary, according to the mode or degree of the local metamorphism to which they have been subjected. The granites, gabbros, etc., in such a region are unaltered plutonic rocks; the quartzites, crystalline limestones, and the like, are probably sediments only partly altered. The gneissoid rocks may be either Archæan or post-Archæan plutonic rocks, or felspathic sediments foliated by pressure, intrusion, veining, and the like. The schists may be either metamorphosed sediments, retaining locally their original bedding (where altered by pyrometamorphism and the like), in dynamo-metamorphic rocks showing only secondary structures, but which may have been originally either gneissic, plutonic, or sedimentary rocks, but whose ingredients have been more or less completely rearranged both structurally and mineralogically. In fine, a metamorphic area is a *petrological complex whose altered rocks have a common foliation*. The *strike of foliation* in such a district is

related to the *general strike of the sheets* of sedimentary or crystalline rocks which formed its main masses at the time of its final folding and shearing; the *dip of foliation* is simply the *local direction of shear,—i.e.* is related to the direction in which the mass to which it belonged was giving way. Like cleavage, it may locally coincide with the original bedding; but it normally crosses the bedding at an angle, and *traverses aqueous and igneous rocks* alike. The planes of schistosity are those planes along which the rocks yielded to the lateral pressure or torsion, and these *yielding planes* may be of *all grades of importance,* from the great overfaults, along which solid masses of enormous extent were thrust forward, in some cases for scores of miles, down to the minutest planes separating the microscopic folia of the slaty schists. These planes cut the rock up into lenticular patches or '*phacoids,*' which, like the yielding planes themselves, are of all gradations of size—from the mountain masses riding out along the great overfolds and overfaults, down to the 'eyes' of the 'augen' schists. The *mechanical effects* wrought by the shearing and deformation of the phacoids show of necessity a corresponding gradation, the conditions at one extreme giving rise to coarse *rock-breccias*; in medium cases to *flaser structures* and foliation; at the other extreme to the compact, stringy *mylonite,* in which the original material has been torn and ground to rock-dust. Parallel with these mechanical changes, but not necessarily accompanying them, we note a series of *chemical changes* of rising grades of importance—a larger and larger portion of the rock undergoing deformation becoming recrystallized, until finally, it may all become transformed into foliated crystalline rock. *The maximum of mechanical effects* seem to have been wrought where the rock yielded to the excessive pressure and torsion mainly along certain *definite planes* (shear planes or gliding planes) or *areas* within the mass; *the maximum chemical effects* where the deforming stresses affected *all the particles* of the *mass* alike, the rock yielding or *flowing* in the manner of a plastic or liquid body. In some minor areas the results effected by dynamo-metamorphism possibly approximate to those wrought by pyro-metamorphism, and we may have what has been called *stratification foliation.* In general, however, the foliated rocks have been sheared, and the primary structures have all been more or less obliterated. But, as a metamorphic region may be subjected to successive earth-movements acting at different times, and from different directions, we occasionally find a newer and more or less incomplete foliation crossing an older foliation, or the rocks may show traces of a foliation of a still earlier date: the successive foliation planes being in different stages of development, preservation, or obliteration."

So much has been done in so little space that it seems greedy to ask for more; still, in the next edition we hope the author may be able to supplant the rest of the old work which he has left; to give us a few more figures of type sections, a little more space to the dates and function of earth-movements, and even perhaps also to the physical geography of the different periods. It seems unnecessary to put into words what it is quite certain all readers will think of

this book; but among the expressions of opinion one will be frequent, that it has those qualities which we always recognize in a man of power—strength and firmness combined with a rare modesty.

II.—List of the Fossil Faunas of Sweden. Edited by the Palæontological Department of the Swedish State Museum (Natural History). I. Cambrian and Lower Silurian. 8vo. 24 pp. III. Mesozoic. 20 pp. (Stockholm, 1888, Printed for the Museum by P. A. Norstedt & Söner.)

The Authorities of the Swedish State Museum intend to publish a list of the fossils (excepting the plants) occurring in the various geological formations of Sweden, and two parts have just been issued. The first of these has been prepared by Prof. G. Lindström, and contains the names of species from the different subdivisions of the Cambrian and Lower Silurian (= Ordovician) in that country. The Cambrian is divided into the following zones, the fossils in each being separately enumerated:—1, Oldest Sandstone Beds, the Eophyton and Fucoid Sandstones; 2, *Paradoxides* Beds, including therein the zones of, (*a*) *Olenellus Kjerulfi*; (*b*) *Paradoxides Œlandicus*; (*c*) *P. Tessini*; (*d*) *P. Davidis*; (*e*) *P. Forchhammeri*; (*f*) *Agnostus lævigatus*; 3, *Olenus* Schists, and 4, *Dictyonema* Slate. The Lower Silurian comprises, 1, *Ceratopyge* Limestone; 2, Lower Graptolite Schists; 3, Orthoceratite Limestone; 4, Middle Graptolite Schists; 5, *Chasmops* Limestone; 6, *Trinucleus* Schists; 7, Brachiopod Schists; 8, Upper Graptolite Schists; and 9, *Leptæna* Limestone. From the Cambrian strata 141 species are enumerated, and 627 from the Lower Silurian, thus making a total of 768 species. Of these no fewer than 365, or nearly one-half, are Trilobites, next in abundance are Graptolites with 146 species, followed by the Brachiopoda with 89 species, and the Cephalopoda with 50 species.

Prof. Lindström remarks that not a single species is recorded as common to the Cambrian and Lower Silurian formations in Sweden, but the latter contains 19 species which recur in the Upper Silurian.

Part II., containing a List of the Upper Silurian Fauna, will be issued in the Autumn; Part III., which has been prepared by Prof. Bernhard Lundgren, records the Mesozoic Fauna. Of the lower portions of the Mesozoic series only the Rhætic and Liassic strata are developed in Sweden, and in these there seems to be but a scanty fauna, for not more than 24 species are enumerated from the former, and 129 from the latter group. There is then a wide gap in the middle portion of the Mesozoic series, until reaching the higher members of the Cretaceous strata, which are richly fossiliferous, the list containing 456 species, mainly from the zones of *Actinocamax mammillatus* and of *Belemnitella mucronuta*.

The value of these Lists, prepared as they have been by such well-qualified authorities, will be recognized by all palæontologists, and we hope that the other parts will be successfully completed.

III.—On the Morphology and Origin of the Ichthyopterygia.[1]
By Dr. Georg Baur, Yale College Museum.

THE present paper is one of the results of Dr. Baur's recent tour in Europe, during which he was enabled to examine the Fossil Vertebrata in most of the principal Museums of the Continent and England. The various known characters of the Ichthyopterygian skeleton are reviewed and compared especially with the existing *Sphenodon*; and the conclusion is arrived at, that these Mesozoic marine reptiles bear the same relation to certain ancestral terrestrial Rhynchocephalia, that is apparently borne by the living Cetacea to early ungulate Mammalia. The skull is only comparable with that of the Rhynchocephalia (especially *Sphenodon*) and the Lacertilia. The only real difference is that, as in the Cetacea, the facial portion has been very much elongated. "The general structure of the skull resembles that of the Dolphins: in its *morphology*, it is a copy of the *Sphenodon* skull." Most of the accepted interpretations of the cranial bones are adopted, but a correction is offered in regard to the large bone forming the postero-external boundary of the supra-temporal fossa. This is determined to be the supratemporal element of the Lacertilia, and in *Sphenodon* is said to be united with the squamosal; the bone in *Ichthyosaurus* has been termed mastoid by Owen, and squamosal by Seeley and Cope. Between this element, the postfrontal, postorbital, quadratojugal, and quadrate, is articulated the true squamosal, named prosquamosal by Owen, and supra-quadrate by Seeley.

After the detailed comparisons, Dr. Baur proceeds to discuss the morphology of the Ichthyosaurian paddle. The most primitive example known is that of *Ichthyosaurus cornalianus*, Bassani, from the Trias of Besano, Italy, which is placed in a new genus, *Mixosaurus*. The radius and ulna are elongated bones, with a considerable intervening space. The paddle of *Baptanodon* or *Sauranodon* is regarded as the most specialized form, and the bone termed by Marsh "intermedium" is interpreted as ulna, while the so-called "ulna" is held as probably representing the pisiforme. The oldest Ichthyopterygia had few phalanges and not more than five digits; later, through the adaptation to the water, the number of phalanges increased, and more digits appeared, chiefly by division of the former, but sometimes by new formation on the ulna side. An interesting analogous case is noted in the manus of a Manatee, in which Dr. Gadow has observed an exceptional increase of the phalanges beyond the normal Mammalian to the number of three.

In conclusion, Dr. Baur proposes the following classification of the Ichthyopterygia:—

Group A. Radius and ulna elongated, separated by a space in the middle. Teeth of two forms, but not so numerous as in the Ichthyosauridæ. Small animals. Triassic.

Family, *Mixosauridæ*, Baur. Genus, *Mixosaurus*, Baur.

Group B. Radius and ulna short bones, touching each other. Teeth well developed and numerous.

[1] *American Naturalist*, 1887, pp. 837–840.

Family, *Ichthyosauridæ*, Bonaparte. Genus, *Ichthyosaurus*, Koenig. Also undefined genera.

Group C. Radius, ulna, and a third bone articulating with the humerus. Teeth rudimentary or absent.

Family, *Baptanodontidæ*, Marsh. Genus, *Baptanodon*, Marsh.

A. S. W.

IV.—"Geology for All." By J. Logan Lobley, F.G.S. (London, Roper & Drowley, 1888.)

"GEOLOGY FOR ALL" is a very attractive title, and we wish that such a work may succeed, for no little credit would attach to the man who could enable the general public to master the alphabet of geology. Outside a limited circle even the well-educated continue in a complete fog as to things which are simple in themselves, and ought to be understanded of the people without difficulty. How far the book in question fulfils this want is a point on which opinions may differ. It is dedicated to the memory of Prof. Morris, and a very good likeness of that best of all geological teachers faces the title-page. Not the least valuable part of this little work consists of the Preface and Introduction, which are full of inducements to pursue the study of geology. When we come to the dry bones of the subject, then a text-book is a text-book, whether it be long or short. On the whole, the author places before his readers a considerable amount of matter of a useful kind within the space allotted to him, though he makes a slip here and there. As, for instance, at page 41, where he is rash enough to give a formula for orthoclase which would yield less than 24 per cent. of silica in a mineral containing over 64 per cent. He is especially strong in dealing with physical features, and his great experience in connection with geological excursions renders this part of his subject comparatively easy to him. We sincerely trust that his ability and enthusiasm may gain many converts to the good cause.

W. H. H.

V.—Free Public Libraries, their Organization, Uses, and Management. By T. Greenwood, F.R.G.S. pp. 320, Illustrated. (Simpkin, Marshall & Co., 1887.)

THIS, though nominally only a fresh issue, is in fact a new edition of the volume which first appeared in 1886. It is printed in a handier form, has undergone revision, and the subject-matter has been re-arranged.

The work "does not seek to be a book of instruction to those in charge of Free Libraries," but is intended to further the extension of the Free Library movement and to aid those who are seeking to secure the adoption of the Libraries' Act in their district by furnishing advice how to initiate and how to carry out the undertaking.

A chapter is devoted to "Museums and Art Galleries,"—and another to "Science and Art"—"in connection with Free Libraries;" but though "Commercial Museums" and "Technical Education" have each their paragraphs, minerals and geological collections have

only an accidental allusion in one case—when the Ipswich Museum and Library are spoken of. Surely some knowledge of Geology, using that term in its widest sense, is both of educational value and technical importance in every district, to say nothing of its extreme usefulness in mining and agricultural centres, and we trust that Mr. Greenwood will in future editions be able to say something in favour of the study of that science which next to chemistry has the greatest influence over the affairs of our every-day life, and thus supply what, to us, seems the one omission in his admirable volume.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 9, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read :—

1. "The Stockdale Shales." By J. E. Marr, Esq., M.A., Sec.G.S., and Prof. H. A. Nicholson, M.D., D.Sc., F.G.S.

The Stockdale Shales extend in an E.N.E.–W.S.W. direction across the main part of the Lake District, parallel with the underlying Coniston Limestone Series and the overlying Coniston Flags, with both of which they are conformable. They also occur in the neighbourhood of Appleby, and in the Sedbergh district. They are divisible into a lower group of black and dark grey and blue Graptolite-bearing shales, interstratified with hard bluish-grey mudstones containing Trilobites and other organisms, and an upper group of pale greenish-grey shales, with thin bands of dark Graptolitic shales. The lower group (Skelgill Beds) are well seen in the stream which runs past Skelgill Farm, and enters Windermere near Low Wood; while the upper group (Browgill Beds) occurs fully developed in the Long Sleddale Valley, and its beds are very fossiliferous in Browgill.

The authors divide these shales into a series of fossil-zones in the following order :—

Stockdale Shales	Browgill Beds	Upper	*Bb* 2	
			Bb 1	
		Lower	*Ba* 2	zone of *Monograptus crispus.*
			Ba 1	,, ,, *turriculatus.*
	Skelgill Beds	Upper	*Ac* 5	,, *Rastrites maximus.*
			Ac 4	,, *Acidaspis erinaceus.*
			Ac 3	,, *Monograptus spinigerus.*
			Ac 2	,, *Ampyx aloniensis.*
			Ac 1	*Monograptus Clingani* band.
		Middle	*Ab* 6	Barren band.
			Ab 5	zone of *Monograptus convolutus.*
			Ab 4	,, *Phacops glaber.*
			Ab 3	,, *Monograptus argenteus.*
			Ab 2	,, *Encrinurus punctatus.*
			Ab 1	,, *Monograptus fimbriatus.*
		Lower	*Aa* 2	,, *Dimorphograptus confertus.*
			Aa 1	,, *Diplograptus acuminatus* and *Atrypa flexuosa.*

Of these zones, the lowest varies, occurring as a thin Limestone

in Skelgill, with *Atrypa flexuosa*, n.sp., and as Graptolitic shale at Browgill with *Diplograptus acuminatus*, Nich. The others appear to run persistently across the district, with the exception of the zone of *Rastrites maximus*, which has only been discovered in the Sedbergh area. The thicknesses, lithological characters, and fossil contents of these zones were considered, and comparisons made between these beds and the corresponding deposits of other areas. The whole group attains a thickness of from 250 to 400 feet, of which the Skelgill beds usually make up about one quarter.

The authors correlate the Graptolite-zones with those of the Birkhill and Bala groups of Professor Lapworth as follows:—

Lake District.		South of Scotland.
Zone of *Monograptus crispus*	=	Zone of *M. exiguus*.
,, ,, *turriculatus*		Not separated.
,, *Rastrites maximus*.........	=	Zone of *R. maximus*.
,, *Monograptus spinigerus* / *Monograptus Clingani* band	=	,, *Monograptus spinigerus*.
Not represented?		,, *Petalograptus cometa*.
Zone of *Monograptus convolutus*.. / ,, ,, *argenteus*.. / ,, ,, *fimbriatus*.	=	,, *M. gregarius*.
,, *Dimorphograptus confertus*	=	,, *Diplograptus vesiculosus*.
,, *Diplograptus acuminatus*...	=	,, *D. acuminatus*.

The zones of *M. convolutus*, *M. argenteus*, and *M. fimbriatus* contain abundance of *M. gregarius*, and the zone of *Dimorphograptus confertus* also contains *Diplograptus vesiculosus* in considerable numbers.

The beds were also compared with the corresponding beds in Sweden, Bohemia, Bavaria, etc., and the fossils other than Graptolites were shown to occur elsewhere in strata of Llandovery-Tarannon age, from which it was concluded that the Stockdale Shales occupy that horizon.

A fault occurs everywhere between the Middle and Lower Skelgill Beds, except perhaps in the Sedbergh district; but it does not seem to cut out a great thickness of rock, and the authors gave reasons for supposing that it was produced by one set of beds sliding over the other along a plane of stratification.

The beds are found to thicken out in an easterly direction, and the possibility of the existence of land in that direction was suggested.

The authors directed attention to the importance of the Graptolitoidea as a means of advancing the comparative study of the stratified deposits of Lower Palæozoic age.

A description was given of the following new species and varieties:—*Phacops elegans*, Boeck & Sars, var. *glaber*, *Cheirurus bimucronatus*, Murch., var. *acanthodes*, *Cheirurus moroides*, *Acidaspis erinaceus*, *Harpes judex*, *H. angustus*, *Ampyx aloniensis*, *Proëtus brachypygus*, and *Atrypa flexuosa*.

2. "On the Eruptive Rocks in the Neighbourhood of Sarn, Caernarvonshire." By Alfred Harker, M.A., F.G.S.

The rocks in question occupy an area about 5¾ miles long from north to south and 2¼ miles broad near the south-western extremity of Caernarvonshire. They were described by the author under the following heads:—

(i.) Granite occupying the northern and north-western part of

the district. The ordinary type is a fairly normal biotite-granite; but a variety at Meillionydd shows an exceptional structure, the biotite moulding the other constituents in ophitic fashion. The granites are intrusive in the Arenig shales.

(ii.) Gabbro, diorite, etc., in two small patches only. The rock, originally a gabbro, passes into diorite, the diallage becoming amphibolized, and the iron-ores disappearing with the production of granular sphene. Near a bounding-fault this hornblendic rock becomes locally schistose and gneissic.

(iii.) Diabase, in the centre, forming the mass of Mynydd-y-Rhiw, and occurring in dykes and sheets near Sarn.

(iv.) Hornblende-diabase showing various relations between the augite and hornblende. Besides the conversion of the former mineral to the latter, a closely similar hornblende has grown as an original border to augite-nuclei. The "secondary-enlargement" of hornblende-crystals is also exhibited.

(v.) Hornblende-picrite in several varieties, forming stratiform banks to a thickness of 250 feet, and surmounted by hornblende-diabase. The two rocks seem to be in close relation to one another, and to have been injected as laccolites between the Upper Arenig strata near Penarfynydd and Rhiw.

(vi.) Dolerite-dykes cutting all the other rocks, and probably Post-Carboniferous and Pre-Permian.

With the exception of the last, all these rocks were referred, on such evidence as is available, to the Bala age.

II.—May 23, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Spheroid-bearing Granite of Mullaghderg, Co. Donegal." By Frederick H. Hatch, Ph.D., F.G.S. Communicated with the permission of the Director-General of the Geological Survey.

This paper deals with a remarkable variety of granite which may be compared with the well-known orbicular diorite or Napoleonite of Corsica. According to Mr. J. R. Kilroe, of the Geological Survey of Ireland, who first discovered this interesting rock, the concretionary balls occur in close juxtaposition in a mass of granite of 5 or 6 cubic yards in size. They have not been found in any other portion of the granite area.

The author first gave a detailed description of the microscopic structure of the normal granite. It is a coarse-grained rock, composed essentially of quartz, orthoclase, microcline, oligoclase, greenish hornblende and black mica. Sphene is an accessory constituent. Since it contains no white mica, the rock belongs to that subdivision of granite which has been termed *granitite*. A description of the spheroidal bodies was then given. The balls are somewhat flattened, the greatest diameter being, in one case, 4 inches, the smallest 3. Each ball consists of two distinct parts, a pinkish central portion (the *nucleus*) and a dark-coloured peripheral or zonal portion (the *shell*). The nucleus consists of an irregular granitic aggregate of oligoclase felspar with a little interstitial quartz. The peripheral

shell is composed chiefly of oligoclase, but also contains abundant included plates of biotite, and over 12 % of magnetic iron-ore. It is to the presence of the last-mentioned mineral that the zonal portion owes its dark colour. By means of a Sonstadt's solution the oligoclase was isolated and analyzed with the following results:—

SiO_2	=	60·99
Al_2O_3	=	25·56
CaO	=	4·88
Na_2O	=	7·73 [1]
Loss on ignition	=	·84
		100·00
Sp. Gr.	=	2·649.

This is the composition of an oligoclase of the formula Ab_3An.

The felspar of the zonal portion is disposed radially, the iron-ore radially and concentrically, while the mica appears to obey no fixed law of arrangement.

A synopsis of the literature concerning the occurrence of similar concretionary bodies in granite was then given, the following authors being referred to:—Leopold v. Buch, Gustav Rose, Allnaud, Charpentier, Jokély, von Andrian, Zirkel, G. W. Hawes, M. de Kronstschoff, J. A. Phillips, vom Rath, Fouqué, Halst, Brögger, and Bäckström.

The conclusion the author arrived at from a consideration of the subject was, that concretionary bodies occurring in granite, may, according to the mode of arrangement of their constituents, be divided into three classes, viz.:—

1. The *concretionary patches* of Phillips.
2. The *granospherites* of Vogelsang.
3. The *belonospherites* of Vogelsang.

The spheroids from Mullaghderg belong to the last-mentioned class. They must be regarded as concretions formed, during the consolidation of the granite magma, by a process of zonal and radial crystallization around an earlier-formed nucleus.

2. "On the Skeleton of a Sauropterygian from the Oxford Clay, near Bedford." By R. Lydekker, Esq., B.A., F.G.S.

A description was given of a considerable portion of the skeleton of a Sauropterygian from the Oxford Clay of Kempston, consisting of several upper teeth, most of the mandible (of which the symphysial region is entire), a considerable number of vertebræ mainly from the "pectoral" and dorsal regions, the greater portion of the two pelvic, and fragments of the pectoral limbs, and a considerable proportion of the pectoral and pelvic girdles. These remains were referred to *Plesiosaurus philarchus*, Seeley, and the various parts described in detail.

The author discussed the advisability of retaining the forms described by various generic names by Professor Seeley, under the name of *Plesiosaurus*, and stated his intention of employing the latter term in its widest sense for the present. With this definition, the form under consideration was shown to present characters inter-

[1] By difference.

mediate between those of *Plesiosaurus* and *Pliosaurus*, but was retained provisionally in the former genus. Although a direct link in the chain connecting the two genera, *P. philarchus* was not regarded as an ancestor of *Pliosaurus*, since teeth undistinguishable from those of the latter genus occur in the Coralline Oolite.

Finally it was concluded that the evidence brought forward was sufficient to render necessary the abolition of the name Pliosauridæ, and the inclusion of *Plesiosaurus* and *Pliosaurus* in a single family.

3. "On the Eozoic and Palæozoic Rocks of the Atlantic Coast of Canada in comparison with those of Western Europe and the Interior of America." By Sir J. W. Dawson, LL.D., F.R.S., F.G.S.

The author referred to the fact that since 1845 he had contributed to the Proceedings of the Geological Society a number of papers on the geology of the eastern maritime provinces of Canada, and it seemed useful now to sum up the geology of the older formations and make such corrections and comparisons as seemed warranted by the new facts obtained by himself, and by other observers of whom mention is made in the paper.

With reference to the Laurentian, he maintained its claim to be regarded as a regularly stratified system probably divisible into two or three series, and characterized in its middle or upper portion by the accumulation of organic limestone, carbonaceous beds, and iron-ores on a vast scale. He also mentioned the almost universal prevalence in the northern hemisphere of the great plications of the crust which terminated this period, and which necessarily separate it from all succeeding deposits. He next detailed its special development on the coast of the Atlantic, and the similarity of this with that found in Great Britain and elsewhere in the west of Europe.

The Huronian he defined as a littoral series of deposits skirting the shores of the old Laurentian uplifts, and referred to some rocks which may be regarded as more oceanic equivalents. Its characters in Newfoundland, Cape Breton, and New Brunswick were referred to, and compared with the Pebidian, etc., in England. The questions as to an Upper Member of the Huronian or an intermediate series, the Basal Cambrian of Matthew in New Brunswick, were discussed.

The very complete series of Cambrian rocks now recognized on the coast-region of Canada was noticed, in connexion with its equivalency in details to the Cambrian of Britain and of Scandinavia, and the peculiar geographical conditions implied in the absence of the Lower Cambrian over a large area of interior America.

In the Ordovician age a marginal and submarginal area existed on the east coast of America. The former is represented largely by bedded igneous rocks, the latter by the remarkable series named by Logan the Quebec Group, which was noticed in detail in connexion with its equivalents further west, and also in Europe.

The Silurian, Devonian, and Carboniferous were then treated of, and detailed evidence shown as to their conformity to the types of Western Europe rather than to those of America.

In conclusion, it was pointed out that though the great systems of formations can be recognized throughout the Northern Hemisphere,

their divisions must differ in the maritime and inland regions, and that hard and fast lines should not be drawn at the confines of systems, nor widely different formations of the same age reduced to an arbitrary uniformity of classification not sanctioned by nature. It was also inferred that the evidence pointed to a permanent continuance of the Atlantic basin, though with great changes of its boundaries, and to a remarkable parallelism of the formations deposited on its eastern and western sides.

4. "On a Hornblende-biotite Rock from Dusky Sound, New Zealand." By Captain F. W. Hutton, F.G.S.

The rock is of eruptive origin, and is associated with Archæan schists and gneisses. It is compact, crystalline, of a dark-green colour, and sp. gr. 3·00—3·07. It is composed of two minerals in nearly equal proportions, one of which, a black mica, has the two optic axes nearly coinciding. The other mineral is of a pale bluish-green colour, and moderately dichroic; it shows an aggregate polarization of rather coarse grains, with here and there distinct crystals of considerable size. Often one side of a crystal shows a single twin, while the other side is polysynthetic. The optical characters are those of the monoclinic system, and further investigation proves these crystals to be hornblende. The mineral which shows aggregate polarization is either crushed hornblende or some altered form of it.

CORRESPONDENCE.

THE CORRELATION OF MIDLAND GLACIAL DEPOSITS WITH THOSE OF LINCOLNSHIRE.

Sir,—It is certainly very desirable that the Glacial Deposits should be correlated with one another, but I do not think any reliable results will be obtained by comparing the descriptions and conclusions which have been published by Mr. Deeley and myself. We have necessarily looked at the beds from different points of view, and I had hoped that Mr. Deeley would have made himself personally acquainted with the tract which lies between the areas we have respectively studied before suggesting anything in the way of correlation.

He thinks that his classification into Older, Middle and Newer Pleistocene might be adopted for Lincolnshire, though the only "Older Pleistocene" deposit known to him in that county is the quartzose sand of Gelston. He suggests, however, that some of the clays classed by me as Newer Glacial may really be older than the Chalky Boulder Clay, and he apparently finds great difficulty in accepting the occurrence of such Newer Glacial Beds at elevations approaching 400 feet. I will only reply that there are many places where he may walk from the eastern plain to the top of the Wold over a continuous sheet of the same kind of Boulder Clay; but when Mr. Deeley can record any facts which seem to support his idea, I shall be quite ready to discuss them.

As regards the Gelston Sand, I must point out that this is an outlying patch, and there is no local evidence to show whether it is older

or newer than the Boulder-clay east of Grantham. Mr. Deeley regards it as older because the material is similar to that of his older Pleistocene sands; he may be right, but neither I nor my colleagues have found any deposits elsewhere in Lincolnshire which could be regarded as distinct from, and older than, the great chalky Boulder-clay.

The only locality where any great mass of Glacial gravel exists is around Benniworth, near Donnington, and this will be described in the forthcoming memoir on Sheet 83 of the Geological Survey Map. There, if anywhere, will Mr. Deeley find the analogue of his Older Pleistocene; but I very much doubt whether clays containing Pennine detritus ever extended so far to the east. If any Older Pleistocene deposits existed in East Lincolnshire, I should expect them to be rather of the Cromer than of the Pennine type.

With regard to the marine origin of the Newer Glacial clays, I would call attention to the remarkable deposits near Kirmington in North Lincolnshire, where laminated loams and sands containing perfect shells are associated with Boulder-clay of the Hessle type in such a way as to lead to the conclusion that they all belong to one group. These beds were carefully studied by Mr. C. Reid, and it is to be hoped that a description of them may soon be published.

The most surprising statement in Mr. Deeley's article is that many geologists regard the glaciated surfaces beneath the Drift of Lancashire as caused by large icebergs grating along the bottom of a sea about 1200 feet deep! He must have strangely misunderstood the views of those who believe the striæ to have been caused by sea-ice, and surely a little consideration will enable him to see that every single striated surface might have been glaciated in shallow water during the progress of a gradual submergence. I certainly never heard of any one who supposed that no such action occurred till the water was 1200 feet deep.

Mr. Deeley has done good work in the Midlands; let me recommend him to take his note-book into Lincolnshire, and when he publishes his observations, to keep his facts rigidly apart from his theories.

SHIRLEY, SOUTHAMPTON. A. J. JUKES-BROWNE.

DISCOVERY OF LOWER CARBONIFEROUS BEDS IN UPPER EGYPT.

SIR,—The discovery of Lower Carboniferous beds in the wild region between the Nile and the Gulf of Suez adds a new feature of interest to the Geology of Egypt. The announcement is contained in a memoir by Dr. Schweinfurth, of Cairo, of which he has been kind enough to forward me a copy containing the result of an exploration by himself and M. Walther, of Jena, into the valley of the Arabah, and communicated to the Egyptian Institute.[1] At first I was somewhat startled by the title and the early pages of the memoir, as the members of the Expedition of the Palestine Exploration Society (1883—4) had failed to notice any Carboniferous beds in the Wâdi Arabah, at the head of the Gulf of Akabah, until we lighted upon

[1] "Sur une récente Exploration Géologique de l'Ouadi Arabah," Le Caire, 1888.

them at Lebrusch, on the flanks of the Moabite hills above the shore of the Dead Sea. I supposed, therefore, that Dr. Schweinfurth had found what we had failed to notice. But, on reading further, the matter was set at rest. It is somewhat unfortunate, and tending to confusion, that there are two Arabah valleys, one in the eastern part of upper Egypt, opening out on the Gulf of Suez, and the other connecting the Gulf of Akabah with the Dead Sea and Jordan Valley. The former is that referred to by the African explorer, and is of special importance as helping to connect the geology of the Upper Nile Valley with that of Arabia Petræa. Dr. Schweinfurth recognizes the identity of the beds he describes with those of the Wadi Nasb in the Sinaitic Peninsula, where limestone containing fossils of Carboniferous Limestone age, first discovered by Mr. Bauerman, are interposed between crystalline rocks and sandstones and other strata of Cretaceous age. These beds were afterwards examined by Col. Sir Charles Wilson and by the Members of the Expedition of 1883—84, and the fossils brought home by them were determined by Prof. Sollas.[1] Of this identification of the beds of the Wadis Nasb and Arabah there can be no question, as the genera of the fossils are in most cases identical, and the species characteristically Carboniferous.

The following is a section of the beds in the escarpment of the southern flank of the plateau of north Galala, descending to the bottom of the Wadi Arabah, in Upper Egypt, as given by Dr. Schweinfurth :—

Summit of Escarpment ; 1400 m. above the sea.

300 m.—Terraines Tertiaires du Parisien.
200 m.—Terraines Tertiaires Londinien (?).
200 m.—Banks of débris covering Cretaceous-beds of Stages *Up. and Lr. Senonien.*
50 m.—Argillaceous and Marly ochreous Limestone and sandy beds with *Ammonites. Senonien inferieur.*
250 m.—Escarpment of red Nubian Sandstone. (*Terrains Crétacés d'incertains étages*).

(Geat Geological hiatus.)

2 m.—Dark Sandstones with silicified wood (*Araucarioxylon*). *Lower Carboniferous.*
60 m.—Solid and soft Sandstones and Marls, with fragments of Crinoids, and *Spirigera.*
1 m.—Bed of hard blue Limestone—with *Crinoids, Productus, Spirifer*, etc.—(Carboniferous Limestone).
40 m.—Marls and Sandstone partly fossiliferous.

Lower Carboniferous.

(Details of beds below this not given.)

GEOLOGICAL SURVEY OFFICE, DUBLIN, 23 *May*, 1888. E. H.

THE ATMOSPHERE OF THE COAL PERIOD.

SIR,—From the silence of your reviewer, I presume that he is unable to verify the assertion so often made that experiments had proved the improbability of plants living in an atmosphere containing an excess of carbonic acid. As I before remarked, very few definite experiments had been made besides the one I have quoted in my work. I might, however, have referred to those made by

[1] "Physical Geology of Arabia Petræa and Palestine," Mem. Palestine Exploration Fund, p. 48.

Daubeny in his Reports to the British Association 1847—1850, "On the Influence of Carbonic Acid Gas on the Health of Plants, especially to those allied to two Fossil Remains found in the Coal-formation." These, although wanting in definite measures and not embracing the whole field of inquiry, are of great value so far as they go, as they confirm at all events the possibility of the original suggestion of Brongniart with respect to the condition of the atmosphere during the Coal Period.

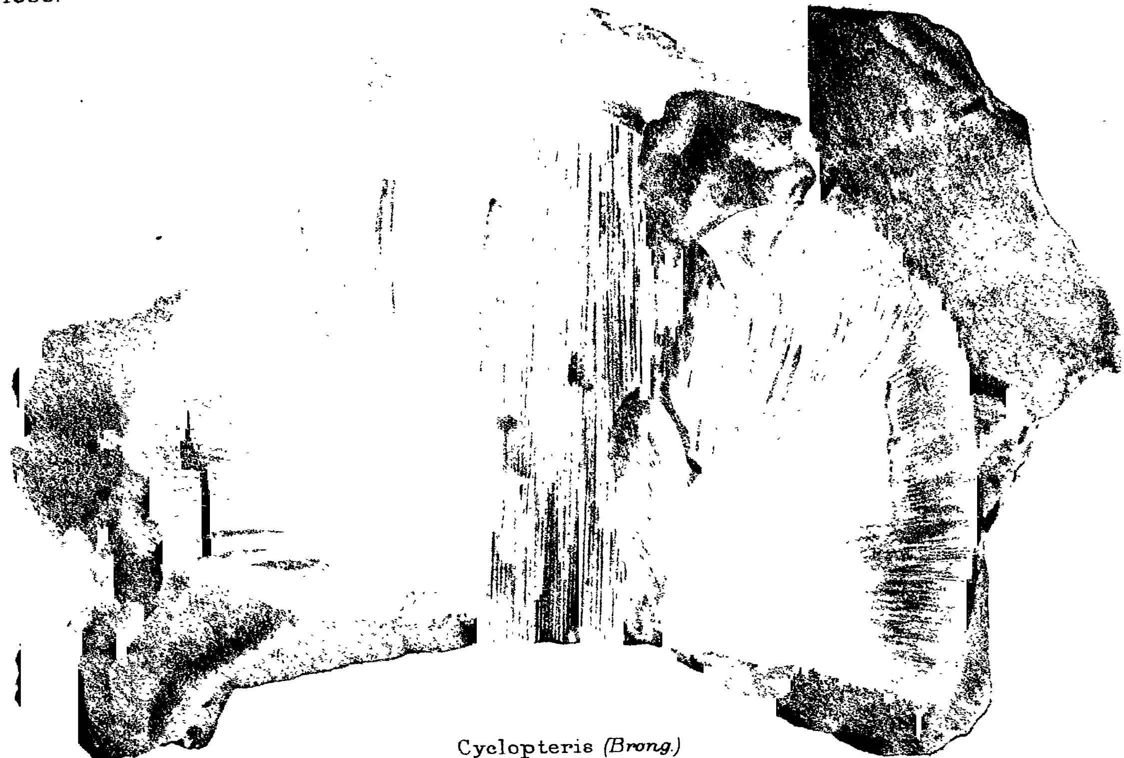
Daubeny showed that *Lycopodium* continued during five weeks in perfect health in an atmosphere containing 5 per cent. of carbonic acid, though species of *Adiantum* appeared less thriving than the corresponding plants not so treated, but that 20 per cent. of carbonic acid proved injurious in two or three days. He also found that Frogs and Newts did not appear to suffer in an atmosphere containing 5 per cent. of the gas. This, however, is a proportion quite excessive and perfectly unnecessary for the object in view, and is therefore beyond the mark. Nevertheless, Daubeny came to the conclusion that the general tenor of his experiments justified him "in inferring that there is nothing in the organization of those plants and animals of the present day which appear most nearly allied to such as were in existence during the Carboniferous epoch, or even somewhat subsequent to that period, militating against the probability, that a larger amount of carbonic acid may have been present in the atmosphere and diffused throughout the waters of the sea and rivers, than is found either in the one or the other at the present time; nor is there anything to prevent us from imagining that the absorption of carbon by vegetables and the consequent rapidity of their growth may, at least within certain limits, have borne some proportion to the greater amount of carbonic acid assumed to have been present at earlier periods in the history of our globe."

Joseph Prestwich.

THE GEOLOGY OF MYNYDD MAWR.

Sir,—I have been much interested in Mr. Harker's description of the rocks of Mynydd Mawr and the Nantlle Valley. His observations on the cleavage structure round the intrusion point it out as a great "eye," whose main axis runs parallel to the cleavage of the district. Last year, while endeavouring to work out the structural relations of the mass, I paid considerable attention to all the junctions, especially those along the S.E. flank. These are everywhere of an obviously intrusive character, the "quartz-porphyry" frequently transgressing upon the bedding of the slates. The main difficulty about the junction to me was that in some places the slates dipped under the intrusive mass, while in others they dipped off it. But I found one section in which the bedding rose vertically, and then bent outwards at an angle of 45°, the porphyry in the upper part resting on the slate. Probably this relation of the two rocks frequently exists round the hill, the lines of rock flowing (if we may use the term) round the intrusion not only in a horizontal but also in a vertical direction.

University Museum, Oxford. W. W. Watts.



Cyclopteris (*Brong.*)
U. Coal Measur s, Yorkshire

West, Newm.

THE

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ORIGINAL ARTICLES.

I.—The Jordan-Arabah Depression and the Dead Sea.

By Israel C. Russell,

Of the United States Geological Survey (Appalachian Division of Geology), Department of the Interior, Washington, D.C., U.S.A.

THE following account of the geology of the Dead Sea basin has been compiled from the observations of others, and I am especially indebted in this connection to H. J. Johnson, Geologist of the United States Expedition to the Dead Sea,[1] to Professor Louis Lartet, Geologist of the Duc de Luynes' Expedition to the same region,[2] and to Prof. Edward Hull, F.R.S., Director of the Geological Survey of Ireland, who visited Arabia Petræa and Palestine in 1883-84, under the auspices of the Committee of the Palestine Exploration Fund.[3] Besides these observers, who devoted their attention specially to the geology of the regions traversed during

[1] This Expedition visited Palestine in 1848, under direction of Lieut. W. S. Lynch. Among its more important contributions to science was the measurement, by means of the spirit level, of the depression of the surface of the Dead Sea below the level of the Mediterranean, the exploration of the River Jordan from the Sea of Galilee to its mouth, and the determination, by sounding, of the depth of the Dead Sea. The results of this Expedition were published in "Official Report of the United States Expedition to the Dead Sea and the River Jordan," by Lieut. F. W. Lynch, U.S.N., Baltimore, 1852; 4to. pp. 1-236, pl. 17, and a map. Also in "Narrative of the United States Expedition to the Dead Sea," by F. W. Lynch, U.S.N., Philadelphia, 1849; 8vo. pp. i-xx, 1-508, pl. 28, and two maps.

[2] This Expedition, fitted out and directed by the Duc de Luynes, visited Palestine and the adjacent regions in 1864; its scientific results include important contributions to geology and palæontology, and a study of the chemistry of the waters of the Dead Sea. Preliminary publications of the results of Louis Lartet's observations while connected with this Expedition, appeared in the "Annales des Sciences Géologiques" for 1869 and 1872. The final report is: "Voyage d'Exploration à la Mer Morte," par M. le Duc de Luynes, Tome Troisième, "Géologie" (Paris, 1877), 4to. pp. i-vi, 1-326, pl. 1-14.

[3] The report of the geological observations made during this Expedition has recently appeared, and is an important and highly interesting contribution to geological science. Its title is: "Memoir on the Geology and Geography of Arabia Petræa, Palestine, and adjoining districts." Published for the Committee of the Palestine Exploration Fund, London [?], 1886. 4to. pp. i-viii, 1-145, pl. 3, and three maps. A narrative of this expedition by the same author, scarcely less important than the final report, is entitled: "Mount Seir, Sinai, and Western Palestine, being a narrative of a scientific expedition," 1883-84, London, 1885. 8vo. pp. i-vi, 1-227, pl. 1-13, and two maps.

their several expeditions, the writer is under obligations to the Ordnance Survey of Palestine, and to many observant travellers, including Condor, Fraas, Tristram, Wilson, and others, for many interesting details and attractive descriptions concerning the regions to which it is desired to direct the reader's attention.

The similarity between the recent geological history of the Dead Sea, and the area of interior drainage in America known as the "Great Basin," with which I have some familiarity, is so marked that I venture to offer a few suggestions and hypotheses, which will, perhaps, be of interest to those who may continue the study of the Geology of Palestine and adjacent regions. I have also inserted a brief account of certain lake-shore phenomena, which have proved of great value in interpreting the ancient histories of several American lakes, which are comparable in many ways with the Dead Sea.

Physical Geology of the Dead Sea Region.

On the west side of the abrupt valley in which the Sea of Galilee, the valley of the Jordan, the Dead Sea, and the Wady Arabah—termed the Jordan-Arabah depression—are situated, lies the table land of Judæa, and the extension southward of the same physical feature known as the plateau of the Tih. The general elevation of this extensive table land is about 2000 feet above the Mediterranean, with occasional eminences attaining a height of from 2500 to 3000 feet. On the east it breaks off in an abrupt escarpment, which forms the western boundary of the Jordan-Arabah depression. This depression is bounded on the east by an escarpment still more rugged and of a greater elevation than on the west. The eastern wall, like the western, exposes the edges of strata which form a vast plateau, known east of the Jordan as the table land of Moab, having a general surface level of about 3000 feet, and farther south as the table land of Edom, the general elevation of which is about 4000 feet above the ocean. The Moab-Edom plateau stretches far to the eastward, with but little change in its physical features, and merges with the Syrian and Arabian deserts, but is not again broken by a sunken area similar to that holding the Dead Sea.

The depression separating the plateaux we have mentioned is from five to nine miles broad, and extends in an approximately north and south direction from the base of Mount Hermon at the north to the Red Sea at the south, a distance of fully 375 miles. Its southern end is occupied for about 100 miles by the waters of the Gulf of Akabah. The length of the Jordan-Arabah depression proper is nearly 250 miles, its southern terminus being at the watershed between the Wady Arabah and the drainage which finds its way toward the Gulf of Akabah.

Considering general features simply, there are two elevated table lands in the south-western part of Asia Minor, separated by a deep, narrow depression or fault valley, which is partially filled by the Dead Sea.

Origin of the Jordan-Arabah Depression.

The observations of Hull, Lartet, Tristram, and others, have shown that this depression has been produced by a fault. In other words, it is due to a fracture in the rocks forming the adjacent table lands, accompanied by a subsidence of the strata on the west side of the fracture in relation to the broken edges of the corresponding beds on the east. The amount of this displacement is not accurately known, and no doubt varies at different portions of the fault line, but is certainly several thousand feet. Judging from the sections published by Hull, 5000 or 6000 feet would be a reasonable minimum estimate. This great fracture follows the base of the escarpment bordering the Jordan-Arabah depression on the east, and passes beneath the Dead Sea near its eastern shore. Its full linear extent is not known, but it has been traced by Hull and others for perhaps 150 miles. Its course is somewhat irregular, and numerous branches or secondary faults are connected with it, but its general bearing throughout its entire course is a few degrees east of north. The hade of the fault plane has not been definitely determined at any locality so far as we can ascertain, but is represented in sections published by various geologists as dipping toward the thrown block at a high angle; that is, it is considered as a normal fault, in distinction from reversed faults, in which the hade is toward the upthrow.

The strata composing the plateaux adjacent to the Dead Sea fault have been but little disturbed except in proximity to the line of fracture, and over large areas are nearly horizontal. The rocks forming these plateaux are Cretaceous limestones and sandstones, resting on rocks of the Carboniferous system, which in their turn are underlain by metamorphic strata perhaps of Archean age, together with igneous rocks of ancient but unknown date. Besides these older formations there are, especially in the neighbourhood of the Sea of Galilee, volcanic dykes and overflows of basaltic lava that are geologically recent.

The formation of the Jordan-Arabah depression, although due to a violent fracturing of the earth's crust, cannot be considered as having been formed suddenly at a single great catastrophe, but, judging from what we know of the formation of similar faults in other regions, must have been of slow growth, accompanied by many earthquakes, and may perhaps be still increasing its displacement. The numerous earth tremors felt in Palestine during the present century may possibly owe their origin to slight slips along this line of fracture.

Lakes in the Dead Sea Basin.

The lacustrine history of the Dead Sea basin began with the time when the fault to which it owes its origin had gained sufficient dimensions to interrupt the previous drainage of the region. This statement is made on the supposition, in the absence of evidence to the contrary, that the south-western part of Asia Minor was a land surface at the time the fault was initiated.

The date of the beginning of this independent drainage system is not definitely known. It was post-Cretaceous, for the reason that Cretaceous rocks form its walls. That it existed as a prominent topographic feature previous to the Glacial epoch is shown by its lacustrine records, taken in connection with the history of adjacent regions during the Quaternary period. Its birth must therefore have been during the Tertiary period.[1]

The best estimate that can be made at present of the extent of the hydrographic basin of the Dead Sea shows that it occupies an area of between nine and ten thousand square miles. The Dead Sea is about 274 square miles in extent.[2] Consequently the ratio of lake surface to drainage area is about as one to thirty-three. The lowest point in the basin is depressed 2570 feet below the level of the Mediterranean, and the lowest point on its rim is 285 feet above the same datum plain, or 1577 feet above the surface of the Dead Sea. It is evident from the present topography that this hydrographic basin must have held a lake in its lowest depression, either continuously or at intervals during humid periods, ever since it was cut off from oceanic drainage.

A lake occupying the Jordan-Arabah depression, like all inclosed lakes, must have been sensitive to climatic changes, and could its past fluctuations be determined in terms of climate, they would furnish a geological weather record of unusual value. In illustration of this it may be observed that as the present arid climate of the Dead Sea basin admits of the existence of a large lake in its lowest depression, it follows that only during periods of excessive aridity could the ratio of evaporation to precipitation be increased sufficiently to cause the lake to disappear. If we could show, therefore, that the Dead Sea was evaporated to dryness, or was greatly concentrated, at any period in its history, we should have proof of the former prevalence of an unusually arid climate in Palestine and adjacent regions. On the other hand, could we show that the Dead Sea once had a much greater expansion than at present, it would be conclusive evidence of a former period of greater mean humidity than the region about it now enjoys.

The fact that the Dead Sea basin has been long isolated is in itself sufficient to suggest that it has an interesting and perhaps highly complex lacustrine history. Fortunately, however, we have observation as well as hypotheses to help us in this connection. From the reports of many explorers we know that the shores of the Dead Sea and the borders of the Jordan valley are scored with terraces, and that lacustrine sediments, in some cases charged with the shells of fresh water mollusks and at other times interlaminated with layers of salt and gypsum, are found over a very large area. Sufficient facts of this nature have been reported by competent observers to show that the Dead Sea basin has a record

[1] Hull places it at the close of the Eocene. Geol. and Geog. of Arabia Petræa, Palestine, etc., p. 108.

[2] Determined from the map accompanying the narrative of the U.S. Expedition. The mean depth of the Dead Sea as obtained from the same map is 500 feet.

of unusual interest inscribed on its walls, much of which is written in such bold characters that he who runs may read.

Before considering the facts that are available in reference to the former climatic condition of Palestine, and the deductions which legitimately flow from them, let us glance briefly at the nature of the records to be looked for, in order to interpret the lacustrine history of an inclosed drainage area of the nature of the Dead Sea basin.

Lacustrine Records.

SEA-CLIFFS.—Waves breaking along a shore tend to undercut it and allow the material forming the land to fall from above. This process, as may be seen on every shore, produces a slope, more or less abrupt, which is termed a sea-cliff. The steepness of such slopes depends on the rate of cutting and on the nature of the material removed. When the work of the waves is rapid, and the shores are formed of material having a high angle of stability, perpendicular, or even over-hanging cliffs are produced. When the wave erosion at the base is less rapid than the atmospheric erosion at the top of a cliff, the slope is less abrupt. The height of cliffs produced in this manner varies from a few feet, or even a few inches, up to many hundred feet. Their bases are horizontal, and at the water line the rock is frequently eaten away irregularly, so as to form caves.

TERRACES.—Waves and currents in cutting away the shores which confine them, remove the material brought within their reach, and as their work progresses landward, form a horizontal shelf or terrace. Such a terrace is bordered on the landward side by a sea-cliff which rises above it, and on the lakeward side by a downward slope, which is usually covered to some extent with debris, derived from the formation of the terrace itself. Terraces of this description are horizontal along the line where the shelf joins the sea-cliff, and slope from this line gently lakeward. When seen in profile, they appear as a notch more or less strongly defined on the slope confining the lake.

Terraces frequently occur at many horizons on the shores of inclosed basins; their relative strength, other things being equal, being determined by the length of time the water lingered at each horizon. When the waters of a lake are withdrawn or greatly lowered, the records of their former levels appear from a distance especially when the shores are steep, as horizontal parallel lines, drawn on the borders of the basin. These lines follow all the irregularities and sinuosities of the shore, and are usually strongest and best defined on promontories and on coasts facing a broad water area. At the heads of sheltered bays, even in the case of lakes of great size, both terraces and sea cliffs are sometimes absent.

A terrace of excavation, the formation of which we have just described, marks definitely the outline of the water surface to which it owes its origin. By following such a terrace one can ascertain if it was ever broken by a channel of overflow, and thus in the case of a desiccated lake basin, determine one of the most important points

in its history. As a terrace when formed is level—with certain slight variations due mainly to the action of the wind in heaping up waters in bays, etc.—a measurement of its present relation to a horizontal plain will indicate whether or not it has been deformed by orographic movement.

The terraces described in the preceding paragraph are terraces of excavation. In nature we find terraces of construction as well. These are formed of the debris cut away from the shore by waves and currents, and spread out as a belt of shingle along the shore, resting usually on a cut terrace. The combination of cut and built terraces is the most common of lake-shore records, and the most easily identified in abandoned lake-basins.

The material removed from the shores of a lake during the cutting of its marginal terraces, together with much of the debris contributed from the land by streams, is removed more or less completely, and after being assorted by the action of waves and currents, is variously distributed. The finer portions remain in suspension for a considerable time, and may be carried away from the land, and on subsiding contribute to the sedimentation of the basin. The coarser portions consisting of sand, gravel and boulders, are too heavy to be floated, and therefore remain in close proximity to the shore. This material is swept along the lake margin by currents, and finally built into beaches, barriers and embankments.

Beaches.—In the formation of beaches the shore debris remains at the lake margin and may coincide with a built terrace, as previously noted, or form a terrace along a shore where no excavation has taken place. In either instance the material composing the beach, usually gravel, is in motion, especially during storms, and is being carried forward to where barriers and embankments are forming.

Barriers.—On lake margins of gentle declivity ridges of gravel and sand are formed at some distance from the shore, but connected at their extremities with terraces or beaches from which the material for their construction is derived. The surfaces of such ridges are horizontal and coincide with the storm limit of the waves and currents to which they owe their origin. They follow the broader sweeps of lake margins but not minor irregularities, and in desiccated lake basins appear like railway embankments. They frequently close the mouths of bays so as to shut them off from communication with the main water body, thus forming lagoons.

Embankments.—When the combined action of waves and currents extends a barrier into deep water, an embankment is formed, which in many cases becomes of very grand proportions. In the formation of embankments the debris of which they are composed is swept along the surface of the barrier or terrace leading to them, and deposited when deep water is reached. This process continues until the embankment has been built up to the water surface. It is then prolonged by material carried along its crest and deposited at its distal extremity. Both bars and embankments, when seen in cross section, having a more or less well-defined anticlinal structure. An arch of this character is termed an "anticlinal of deposition." The

elevations of the horizontal surfaces of barriers and embankments, in the case of fossil lakes, furnish the most accurate of all shore records for determining former water levels.

DELTAS.—A delta formed by a high grade stream, when seen in section, presents a well-marked tripartite structure. The middle member consists of water-worn gravel, more or less thoroughly assorted, in layers sloping lakeward at an angle corresponding with its angle of stability in water. The thickness of this deposit increases as the delta is advanced, and in lakes with precipitous borders may become several hundred feet deep near the lakeward margin. Beneath the inclined gravels, especially in the case of deltas that have been prolonged some distance into a lake, are lacustrine clays and marls, which are usually crumpled and otherwise deformed, owing to the weight of the mass of material superimposed upon them. Above the inclined gravel is a deposit of unassorted or irregularly assorted debris, which is thinnest toward the periphery of the delta and thickest towards its apex. The history of the growth of a delta may be inferred from its structure, and need not be described here.

We have not attempted even a sketch of all the features of lake shores that are of assistance to the geologist in determining the history of a fossil lake, partially for want of space, but principally for the reason that an exhaustive analysis of lake-shore phenomena is already accessible to the student.[1]

MECHANICAL SEDIMENTS AND CHEMICAL PRECIPITATES.—The deposits usually formed in lakes, as is well known, are evenly stratified clays and marls, which are in many instances charged with shells. When lakes are without outlet, however, and become saline owing to the concentration of their water by evaporation, their faunas are exterminated or greatly modified, and the mineral matter held in solution is precipitated when the process has progressed sufficiently. If concentration continues without interruption, there will be a regular sequence in the precipitates formed, beginning under normal conditions, with calcium carbonate, followed by calcium sulphate, sodium chloride and other salts.

Chemical precipitates originating in the manner mentioned above may be deposited on the sides of a lake basin with rocks and stones for nuclei, as is the case very commonly with incrustations of calcareous tufa; or they may be precipitated generally over the lake bottom and become mingled with clays and marls deposited simultaneously. When sedimentation is taking place but slowly, layers of various salts may attain a depth of many feet, and should uniform conditions continue, may even become hundreds of feet in thickness. After the precipitation of saline deposits of this nature a lake might expand owing to a climatic change and be freshened either on account of the increase in supply, or by the waters rising sufficiently to find an outlet, and thus flood out the previously concentrated brine. In such instances the beds of calcareous tufa, gypsum and common

[1] "The Topographic Features of Lake Shores," by G. K. Gilbert, in Fifth Annual Report of the U. S. Geological Survey, 1883-84, Washington, 1885.

salt precipitated during the period of concentration, might become buried beneath layers of marl and clay abounding in the remains of mollusks and fishes.

With this imperfect lesson on what is taking place in lakes at the present day, let us return to the Dead Sea.

(To be concluded in our next Number.)

II.—Woodwardian Museum Notes. On a Specimen of *Cyclopteris* (Brongniart.)

By Albert C. Seward, B.A., F.G.S.,
Foundation Scholar of St. John's College, Cambridge.

(PLATE X.)

The specimen of which I give below a brief description is of some interest as adding to the store of facts which may help us in the elucidation of the obscure genus *Cyclopteris*. So far as I know such large *Cyclopteris* leaves have not been previously figured attached to a rachis.

The described specimen, which I have placed in the Woodwardian Museum, was given to me by Mr. Walter Hemingway, of Barnsley, who found it in the Upper Coal-measures of Brierly Common, Yorkshire. When first seen[1] the rachis was 4ft. 2in. long, and had five pairs of pinnules, the distance between each pair decreasing towards the thinner end of the rachis. Unfortunately it was impossible to get the fossil out whole, only two pairs of pinnules being obtained in a perfect state.

Frond pinnate. Pinnules suborbicular; sessile; apparently lobed at the base, the lobes resting on the rachis: the lower margin of the pinnules is somewhat abruptly cut off as if the present shape might be due to tearing or imperfect preservation, the original pinnule having probably a more rounded or tapering base. No midrib, the nervures radiate from the basal portion of the pinnules and frequently dichotomise as they proceed towards the margin, where they are delicate and numerous.

The rachis is represented by a raised portion of the stone, which is finely striated longitudinally, the striæ being somewhat irregular, and not continuous from one end to the other: a few isolated fragments of carbanaceous matter represent the original cortical tissues of the rachis.

Length of rachis shown in figure 8 cm.; breadth 2 cm.; pinnules in longest part 7 cm.; greatest breadth 5 cm.

The genus *Cyclopteris* established by Brongniart in 1828, is defined by him as follows:[2]—"Fronde simple, entière, le plus souvent orbiculaire ou réniforme; nervures nombreuses toutes égales, dichotomes, rayonnant de la base." The essential generic characters being the absence of a midrib, and the basal origin of the nervures. In the "Histoire des végétaux fossiles"[3] Brongniart figures several

[1] I am indebted to Mr. Hemingway for these facts.
[2] Prodrome d'une hist. des végét. foss. p. 51 (1828).
[3] Hist. des végét. foss. plates 61 and 61 bis. (1828–1837).

species of *Cyclopteris*, none of which exactly correspond to my specimen, *Cyclopteris obliqua*, which is represented as an isolated petiole, being the most like it. In his later work[1] Brongniart divides the Cyclopteroid forms into two genera, *Cyclopteris* and *Nephropteris*: the former he defines as follows:—"Fronde simple, pédicellée, symétrique, arrondie, cordiforme, ou flabellée, entière ou lobée, sans apparence de nervure médiane, toutes les nervures partant de la base du limbe, et se divisant en se dichotomant pour atteindre la circonférence."

Cyclopteris reniformis, C. trichomanoides, C. digitata, etc., belong to this genus.

The genus *Nephropteris* which is thus defined:—"Frondes isolées, simples, sessiles, obliques, non symétriques, arrondies ou cordiformes, ordinairement concaves et ombiliquées à leur base"—includes such forms as *Cyclopteris obliqua, C. oblata, C. orbicularis*, etc. These species are regarded by Brongniart as a distinct group; he considers them to be anomalous basal leaves, referable probably to the genera *Neuropteris* and *Odontopteris*.

Lindley and Hutton[2] give two figures of *Cyclopteris obliqua*; they point out that the absence of any stalk and the trace of what seems to them a distinct disarticulation favour the idea that the specimens originally formed parts of compound leaves. This being the case, they consider them referable to *Neuropteris* rather than *Cyclopteris*.

It is also suggested by these authors[3] that *Neuropteris ingens* may have belonged to the same plant as *Cyclopteris obliqua*.

In the "Illustrations of Fossil Plants," edited by Prof. Lebour,[4] there is a figure of *Cyclopteris* (*Nephropteris*) *obliqua* which shows two pinnules attached to a rachis; this specimen closely resembles the one I have figured, except in its much smaller size.

In his earlier writings Lesquereux[5] retains the genus *Cyclopteris*, and considers that all Cyclopteroid leaves attached to stems form a distinct genus: those without stems and with arched nervures are included in *Neuropteris*, those without stems and with straight and diverging nervures are classed with *Odontopteris*. The Cyclopteroid leaves with stems are retained in the genus *Cyclopteris*, which is subdivided into three sections:—(α) Adianthoides. (β) Odontopteroides. (γ) Neuropteroides.

In the description of fossil plants in the Report of the Geological Survey of Illinois, Lesquereux[6] no longer regards *Cyclopteris* as a distinct genus, further evidence having been obtained in favour of the connection of *Neuropteris* and *Cyclopteris*. *Neuropteris* is defined so as include leaflets without a median nervure.

1 Tableau des genres de végét. foss., considérés sous le point de vue de leur classification botanique et de leur distribution gélogique, p. 16 (1849).

2 Fossil Flora, pl. 90 (1831-1837).

3 Fossil Flora, vol. ii. p. 28.

4 Illust. of Fossil Plants, p. 23, pl. 11.

5 Description of Fossil Plants in Geology of Pennsylvania, by H. D. Rogers, vol. ii. (1858).

6 Description of Fossil Plants in Report Geol. Survey of Illinois, vol. ii. p. 427 (1866).

In the Palæontographica for 1868–69,[1] Roehl figures a large specimen showing *Neuropteris Loshii* and *Cyclopteris trichomanoides* on the same rachis. In his description of *Neuropteris Loshii* he remarks :[2]—"On the axis or a very large frond I found *Cyclopteris trichomanoides* (Brongt.), which hitherto had only been found by itself, grown as axial leaves ('Spindelblätter') of this plant." The Cyclopteroid leaves are in this case only attached to one side of the rachis: the size and striated character of the rachis closely connect it with my specimen. Schimper[3] figures some examples under the name of *Cardiopteris frondosa* (Göpp.), showing large pinnules attached to a rachis: the nervation and the comparatively equilateral form of these pinnules resemble Neuropteroid rather than Cyclopteroid leaves, of which latter mine is an example. Feistmantel,[4] in describing the genus *Cyclopteris*, points out that if it is established that many of the species of *Cyclopteris* are basal or axial leaves ("Basal—oder Spindel—blättchen") of *Neuropteris*, other species have the characteristics of *Cyclopteris* as defined by Brongniart, viz. absence of a median nervure, and the dichotomous and flabellate character of the nervures which spring from the base of the pinnules. The figures[5] given by Feistmantel of Göppert's *Cyclopteris polymorpha* show the pinnules attached to a rachis, but the nervures appear to start from the centre of the base as they do in *Cardiopteris frondosa* (Göpp.).

Grand'Eury[6] refers some specimens of *Cyclopteris* to *Neuropteris*, and others to *Odontopteris*; he considers *Cyclopteris obliqua* and *C. oblata* to be merely detached pinnules of *Neuropteris*.

Mr. Kidston,[7] in his catalogue of Palæozoic plants in the British Museum, goes so far as to drop the genus *Cyclopteris* entirely; he considers *Cyclopteris dilatata*, *C. obliqua*, etc., to belong to *Neuropteris heterophylla* and refers to Roehl's figure in support of this view. He points out how the pinnules of *Neuropteris Scheuchzeri* (Hoff.) vary in form, some being the typical acute forms and others belonging to the Cyclopteroid type. The shape of the pinnules varies so much that it is of no specific value. In the absence of such evidence as is afforded by fructification, we must rely to a great extent on the arrangement of the nervures. In my specimen the pinnules appear to be almost opposite on the rachis, but this is of no great importance, as Mr. Kidston remarks,[8] "the alternate or opposite arrangement of pinnæ or pinnules appears to be a character of little value, as they are frequently alternate and opposite on different parts of the same frond."

Through the kindness of Prof. Lebour and Mr. Howse I was allowed to examine the Hutton collection of plants in the Newcastle Museum; in this collection there is a specimen showing a pinnule

[1] Palæontographica, vol. xviii. taf. xvii.
[2] *Ibid.* p. 37.
[3] Traité de Pal. végét. pl. xxxv. (1869–74).
[4] Zeitsch. der Deutsch. Geolog. Gesell. Band xxi. p. 521.
[5] *Ibid.* taf. xvi. figs. 21–24.
[6] Flore Carb. du Depart. de la Loire, etc. p. 379 (1877).
[7] Catalogue of the Pal. Plants in the British Museum, p. 90 (1886).
[8] *Ibid.* p. 84.

of *Cyclopteris obliqua* attached to a thick rachis 23 cm. in length, the pinnule is not perfectly preserved, and there are no signs of a corresponding one on the other side; the rachis is of similar appearance to the one in my specimen.

In the present state of our knowledge it would be premature to speak positively as to the claims of *Cyclopteris* to be considered a distinct form, the specimen before us, however, seems to justify our retaining for the present Brongniart's original genus.

III.—Recent Observations on the Glaciation of British Columbia and Adjacent Regions.

By Geo. M. Dawson, D.Sc., F.G.S.,
Assistant Director, Geological Survey of Canada.

PREVIOUS observations in British Columbia[1] have shown that at one stage in the Glacial period—that of maximum glaciation —a great confluent ice-mass has occupied the region which may be named the Interior Plateau, between the Coast Mountains and Gold and Rocky Mountain Ranges. From the 55th to the 49th parallel this great glacier has left traces of its general southward or south-eastward movement, which are distinct from those of subsequent local glaciers. The southern extensions or terminations of this confluent glacier, in Washington and Idaho Territories, have quite recently been examined by Mr. Bailley Willis and Prof. T. C. Chamberlin, of the U.S. Geological Survey.[2] There is, further, evidence to show that this inland-ice flowed also, by transverse valleys and gaps, across the Coast Range, and that the fiords of the coast were thus deeply filled with glacier-ice which, supplemented by that originating on the Coast Range itself, buried the entire great valley which separates Vancouver Island from the mainland and discharged seaward round both ends of the island. Further north, the glacier extending from the mainland coast touched the northern shores of the Queen Charlotte Islands. The observed facts on which these general statements are based have been fully detailed in the publications already referred to, and it is not the object of this note to review former work in the region further than to enumerate the main features developed by it, and to add to these a summary of observations made during the summer of 1887 in the extreme north of British Colombia, and in the Yukon basin beyond the 60th parallel, which forms the northern boundary of that province.

The littoral of the south-eastern part or "coast strip" of Alaska presents features identical with those of the previously examined coast of British Columbia, at least as far north as lat. 59°, beyond which I have not seen it. The coast archipelago has has evidently been involved in the border of a confluent glacier which spread from the mainland and was subject to minor variations

[1] Quart. Journ. Geol. Soc. vol. xxxi. p. 89. *Ibid.* vol. xxxiv. p. 272. Canadian Naturalist, vol. viii.

[2] Bulletin U.S. Geol. Survey, No. 40, 1887.

in direction of flow dependent on surface irregularities, in the manner described in my report on the northern part of Vancouver Island.[1] No conclusive evidence was here found, however, either in the valley of the Stikine River or in the pass leading inland from the head of Lynn Canal, to show that the ice moved seaward across the Coast Range, though analogy with the coast to the south favours the belief that it may have done so. The front of the glacier must have passed the outer border of the Archipelago, as at Sitka, well-marked glaciation is found pointing toward the open Pacific[2] (average direction about S. 81° W. astr.). It is, however, in the interior region, between the Coast Range and the Rocky Mountains proper and extending northward to lat. 63°, explored and examined by us in 1887, that the most interesting facts have come to light respecting the direction of movement of the Cordilleran glacier. Here, in the valleys of the Pelly and Lewes branches of the Yukon, traces were found of the movement of heavy glacier-ice in a northerly direction. Rock-surfaces thus glaciated were observed down the Pelly to the point at which it crosses the 136th meridian and on the Lewes as far north as lat. 61° 40′, the main direction in the first-named valley being north-west, in the second north-north-west. The points referred to are not, however, spoken of as limiting ones, for rock exposures suitable for the preservation of glaciation are rather infrequent on the lower portions of both rivers and more extended examination may result in carrying evidence of the same kind much further toward the less elevated plains of the Lower Yukon. Neither the Pelly valley nor that of the Lewes is hemmed in by high mountainous country except toward the sources, and while local variations in direction of the kind previously referred to are met with, the glaciation is not susceptible of explanation by merely local agents, but rather implies the passage of a confluent or more or less connected glacier over the region.

In the Lewes valley, both the sides and summits of rocky hills 300 feet above the water were found to be heavily glaciated, the direction on the summit being that of the main (north-north-west) orographic valleys, while that at lower levels in the same vicinity followed more nearly the immediate valley of the river, which here turns locally to the east of north.

Glaciation was also noted in several places in the more mountainous country to the south of the Yukon basin, in the Dease and Liard valleys, but the direction of movement of the ice could not be determined satisfactorily, and the influence of local action is there less certainly eliminated.

Of the glacial deposits with which the greater part of the area of the inland region is mantled, it is not intended here to give any details, though it may be mentioned that true Boulder-clay is frequently seen in the river-sections, and that this generally passes upward into, and is covered by, important silty beds, analogous to

[1] Annual Report Geol. Surv. Canada, 1885, p. 100 B.

[2] Mr. G. F. Wright has already given similar general statements with regard to this part of the Coast of Alaska, American Naturalist, March, 1887.

the silts of the Neohacoo basin, further south in British Columbia, and to those of the Peace River Country to the east of the Rocky Mountains. It may be stated also that the country is generally terraced to a height of 4000 feet or more, while on an isolated mountain-top near the height of land between the Liard and Pelly rivers (Pacific-Arctic watershed) rolled gravel of varied origin was found at a height of 4300 feet, a height exceeding that of the actual watershed by over 1000 feet.

Reverting to the statements made as to the direction of the general glaciation, the examination of this northern region may now be considered to have established that the main gathering-ground or *névé* of the great Cordilleran glacier of the west coast, was included between the 55th and 59th parallels of latitude in a region which, so far as explôred, has proved to be of an exceptionally mountainous character. It would further appear that this great glacier extended, between the Coast Range and the Rocky Mountains, south-eastward nearly to lat. 48°, and north-westward to lat. 63°, or beyond, while sending also swollen streams to the Pacific Coast.

In connection with the northerly direction of ice-flow here mentioned, it is interesting to recall the observations which I have collected in a recently published report of the Geological Survey, relating to the northern portion of the continent east of the Mackenzie River.[1] It is there stated that for the Arctic coast of the Continent, and the Islands of the Archipelago off it, there is a considerable volume of evidence to show that the main direction of movement of erratics was *northward.* The most striking facts are those derived from Prof. S. Haughton's Appendix to M'Clintock's Voyage, where the occurrence is described of boulders and pebbles from North Somerset, at localities 100 and 135 miles north-eastward and north-westward from their supposed points of origin. Prof. Haughton also states that the east side of King-William's Land is strewn with boulders of gneiss like that of Montreal Island, to the southward, and points out the general northward ice-movement thus indicated, referring the carriage of the boulders to floating-ice of the Glacial Period.

The copper said to be picked up in large masses by the Eskimo, near Princess-Royal Island, in Prince-of-Wales Strait, as well as on Prince-of-Wales Island,[2] has likewise, in all probability been derived from the copper-bearing rocks of the Coppermine River region to the south, as this metal can scarcely be supposed to occur in place in the region of horizontal limestone where it is found.

Dr. A. Armstrong, Surgeon and Naturalist to the "Investigator," notes the occurrence of granitic and other crystalline rocks not only on the south shore of Baring Land, but also on the hills at some distance from the shore. These, from what is now known of the region, must be supposed to have come from the continental land to the southward.

[1] Notes to accompany a Map of the Northern Portion of the Dominion of Canada, East of the Rocky Mountains, p. 57 R., Annual Report, 1886.

[2] De Rance, in Nature, vol. xi. p. 492.

Dr. Bessels, again, remarks on the abundance of boulders on the shore of Smith's Sound in lat. 81° 30′, which are manifestly derived from known localities on the Greenland coast much further southward, and adds, "Drawing a conclusion from such observations, it becomes evident that the main line of the drift, indicating the direction of its motion, runs from south to north." [1]

It may further be mentioned that Dr. R. Bell, of the Canadian Geological Survey, has found evidence of a northward or north-eastward movement of glacier-ice in the northern part of Hudson Bay, with distinct indications of eastward glaciation in Hudson Strait.[2] For the Northern part of the Great Mackenzie Valley we are as yet without any very definite information, but Sir J. Richardson notes that Laurentian boulders are scattered westward over the nearly horizontal limestones of the district.

Taken in conjunction with the facts for the more southern portion of the Continent, already pretty well known, the observations here outlined would appear to indicate a general movement of ice outward, in all directions, from the great Laurentian axis or plateau which extends from Labrador round the southern extremity of Hudson Bay to the Arctic Sea; while a second, smaller, though still very important region of dispersion—the Cordilleran glacier-mass—occupied the Rocky Mountain region on the west, with the northern and southern limits before approximately stated.

I have refrained from entering into any detail at this time in respect to the glaciation of the northern part of the Cordillera belt, as it is probable that within the year we shall be more fully informed on the subject, as the result of observations to be expected from Mr. R. G. M'Connell of this Survey. Mr. M'Connell is now on the Mackenzie River, which, as well as the Porcupine branch of the Yukon, within the Arctic circle, it is intended that he shall examine during the summer.

IV.—Notes on the Sauropterygia of the Oxford and Kimeridge Clays, mainly based on the Collection of Mr. Leeds at Eyebury.

By R. Lydekker, B.A., F.G.S., etc.

I PRESUME that most English students of Mesozoic Reptiles are acquainted, at least by report, with the magnificent collection of the remains of Sauropterygians and other Saurians from the Oxford Clay of Northamptonshire in the possession of Mr. A. N. Leeds, of Eyebury, near Peterborough. Those, however, who have not had the good fortune to see this unrivalled collection, can have no idea of its richness, or of the light it throws on the organization and affinities of the Sauropterygians of the later Jurassic seas. Till a few weeks ago I was among the number of those to whom this collection was known merely by report: but at the end of June I availed myself of Mr. Leeds' courteous invitation to see and study his

[1] Nature, vol. ix.

[2] Annual Report Geol. Surv. Canada, 1885, p. 14 D.D.; and Report of Progress, 1882-84, p. 36 D.D.

collection as fully as I might desire. On arrival, my astonishment was unfeigned to find that this collection comprised not, as I expected, only one or two imperfect skeletons of one or more species, but in some cases as many as five or six almost entire skeletons belonging to as many individuals of four well-defined species. The specimens are arranged on shelves and in trays in two rather small rooms, which they almost completely fill; and so perfect are many of them that there would be no great difficulty in mounting entire skeletons of these extinct Saurians in the same manner as those of existing Cetaceans are exhibited in our Museums. In many cases every process and spine of the vertebræ is absolutely perfect, owing to the careful and patient manner in which Mr. Leeds has personally extracted the skeletons from the soft clay in which they lay embedded. The paddles too, which have been such a stumbling-block to the palæontologist, have every bone in its natural position, so that there can no longer be any doubt as to their mode of arrangement.

Apart, however, from the intrinsic perfection of this collection, its great importance consists in the clearing up of the relations and affinities of the many so-called species of Sauropterygians which have been described upon more or less imperfect remains from the Oxford Clay. In order to avail myself of the full advantages to be gathered from a visit to this collection, I had carefully studied all the specimens previously described from this horizon; and, through the courtesy of Prof. A. H. Green, I had the further advantage of having the type vertebræ on which the late Professor Phillips founded his *Plesiosaurus Oxoniensis* and *P. plicatus* at the British Museum.

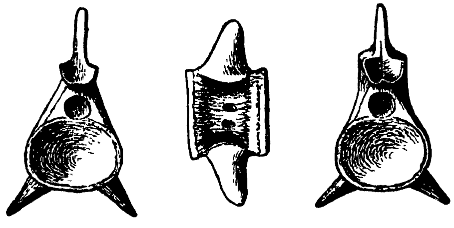


FIG. 1.—Posterior (1), hæmal (2), and anterior (3) aspects of a cervical vertebra of *Plesiosaurus plicatus*, from the Oxford Clay, ⅓. (After Phillips.)

The first skeleton to which I directed my attention was the somewhat imperfect one which Prof. H. G. Seeley described some years ago in vol. xxx. of the Geological Society's Journal, under the new generic and specific name of *Murænosaurus Leedsi*. Since that specimen was found Mr. Leeds has obtained several other much less imperfect skeletons of both immature and adult individuals, which he refers, and in my judgment quite correctly, to the same species. The immature skeletons show, however, that the cervical vertebræ are quite indistinguishable from those from the Oxford Clay near Oxford, to which Prof. Phillips applied the name *P. plicatus* (Fig. 1); and the specific name *Leedsi* must, therefore, yield place to this earlier one. The most important point, however, on which these new skeletons throw

light is the structure of the pectoral girdle. It will be remembered that the genus *Murænosaurus* was founded upon a supposed peculiarity of this part of the skeleton—to wit, that the preaxial border of the coracoids was not connected by a median bony bar with the pre-coracoids (using the terms employed by Mr. J. W. Hulke). Now the new specimens show that this restoration of the pectoral girdle is solely due to the imperfection of the type specimen; and, as Mr. Leeds at once pointed out to me, the portion of the scapulo-precoracoid regarded as the precoracoid in the figure given in the Q J.G.S. vol. xxx. p. 448, and made to meet its fellow in the middle line, is really the dorsal part of the scapula. The pectoral girdle is in fact of the same general structure as that figured by Prof. Seeley on p. 447 of the same volume as the type of the so-called *Colymbosaurus*; and there appears to be no distinction, so far as regards the pectoral girdle (on which the two were founded), of both *Murænosaurus* and *Colymbosaurus* from the earlier *Elasmosaurus* of Prof. Cope. If, however, we follow Mr. Hulke in retaining the Jurassic and Cretaceous Sauropterygians exhibiting this modification of the pectoral girdle in the original genus *Plesiosaurus*, of which they form a well-marked group, then we may continue to use the name *Plesiosaurus plicatus* for this species. An allied, and apparently unnamed species, represented in Mr. Leeds' collection, and distinguished by its shorter cervical vertebræ, which are also fewer in number, is also known to me by a considerable portion of a skeleton obtained from the Oxford Clay of Weymouth. This form I shall describe, and if necessary name on a future occasion; Mr. Leeds having kindly lent me one of the cervicals of his mature example.

The next species I have to mention is *P. Oxoniensis*, represented by several nearly entire skeletons in the Eyebury Collection. Of the specific identity of these examples I have satisfied myself by a comparison with the type cervical and dorsal vertebræ in the Oxford Museum. This species was referred by Prof. Seeley to a subgenus of *Murænosaurus*—I presume on the evidence of a pectoral girdle figured in Phillips's "Geology of Oxford" (p. 310), which is turned the wrong way upward and described as the pelvis. The coracoids (pubes) in that example are, however, I believe, referable to the so-called *Plesiosaurus philarchus*; and the Eyebury specimens show that the pectoral girdle was of the type of the so-called *Colymbosaurus*. These specimens show, moreover, that the remarkable pectoral limb from the Oxford Clay of Bedford, figured by Phillips on p. 315 as a pelvic limb, and made the type of *P. eurymerus*, is really referable to *P. Oxoniensis*; the limb figured on p. 312 of the "Geology of Oxford" under the latter name apparently belonging to *P. plicatus*.

A fourth species represented in Mr. Leeds' collection is the so-called *Plesiosaurus philarchus* of Prof. Seeley, characterized by its long mandibular symphysis. The examples of this species show that in the young there were two distinct costal facets in the cervical vertebræ; while the teeth, and pectoral and pelvic girdles, present a great resemblance to those of *Pliosaurus*. This species seems to

be closely allied to *Thaumatosaurus oolithicus*, of the Lower Jurassic of Würtemberg, in which the teeth have the same structure and the cervical vertebræ are likewise furnished with two costal facets. The latter species, again, appears to come so close to the Upper Liassic *Plesiosaurus Cramptoni*—the type of Prof. Seeley's genus *Rhomaleosaurus*—that with our present material not even specific characters can be recognized. On these grounds I am inclined to include all these three species, together with the Lower Liassic *P. megacephalus*, in a single genus, for which the name *Thaumatosaurus* should be adopted. This reference I shall again have occasion to mention in an addendum to a paper on the Oxfordian species in the "Geological Society's Journal"; the knowledge I have gained since that paper was read having induced me to remove that species from the genus *Plesiosaurus*. Mr. Leeds' examples show that a small omosternum was present.

Of the genus *Pliosaurus* Mr. Leeds possesses only a number of detached teeth, which differ from those of the Kimeridgian forms in the imperfect development of the "carinæ," and the absence of the distinct smooth and flat intercarinal space. These teeth appear indistinguishable from the one from the Oxfordian of Boulogne described and figured by M. Sauvage under the name of *Liopleurodon ferox*. I can see, however, no reason why this species should be separated from the Owenian genus, and it may accordingly be known as *Pliosaurus ferox*. The cervical vertebræ from the Oxford Clay in the Cambridge Museum to which Prof. Seeley has applied the name *P. pachydirus*, without, however, giving any specific diagnosis, are probably referable to the same species.

Leaving now the Eyebury Collection with the expression of my thanks to its owner for his courtesy in placing it thus freely before me, our attention may be directed in the remaining part of this paper to certain large Plesiosaurian remains from the Kimeridge Clay, which are allied to *P. Oxoniensis*. In the first place I may mention that after leaving Peterborough I availed myself of the permission of Mr. Marshall Fisher, of Ely, to visit his collection, which contains the pectoral girdle figured by Prof. Seeley on p. 447 of the thirtieth volume of the "Geological Society's Journal," under the name of *Colymbosaurus*, and thence proceeded to the Woodwardian Museum at Cambridge to have one more look at the vertebral column to which the same authority has given the name of *Plesiosaurus megadirus*; both specimens being from the Kimeridge Clay of the Cambridgeshire district.

Before going further it is, however, necessary to recapitulate briefly the history of these large Kimeridgian Plesiosaurs. In the "British Association Report" for 1839, Sir R. Owen described a propodial bone (humerus or femur) of a large Plesiosaur from the Kimeridge Clay of Shotover in the collection of the late Lord Enniskillen, under the name of *Plesiosaurus trochanterius*; this specimen being now in the British Museum. Its structure is shown in the accompanying woodcut of another example. In the year 1841 this species, together with *P. grandis*, was referred to the genus *Pliosaurus*; of which the

type is *P. brachydirus*, described in the previous year in the same writer's "Odontography." In 1869 Prof. Seeley, in his "Index to the Woodwardian Museum," applied the name *Plesiosaurus megadirus* to the above-mentioned vertebral column in the Cambridge Museum; merely, however, mentioning its large size and the number of the cervical vertebræ, and the description being therefore insufficient to authenticate the name. A second imperfect skeleton, in the same collection (presented by Mr. Stead Jones), was referred to the same species; that specimen having a propodial of the peculiar type of *P. trochanterius*. In the following year Mr. Hulke described in the Q.J.G.S. vol. xxvi. the vertebral column, the pectoral and pelvic propodials, and the imperfect coracoids of a large Plesiosaur from the Kimeridge Clay of Dorsetshire under the name of *P. Manseli*; and also certain dorsal vertebræ remarkable for their very short centra, to which the name *P. brachistospondylus* was accordingly applied. In the course of the description of the former species the resemblance of the propodials to the type of *P. trochanterius* was pointed out, and no very good reasons were given why the specimen should not have been referred to that species, which was thus proved to be Plesiosaurian.

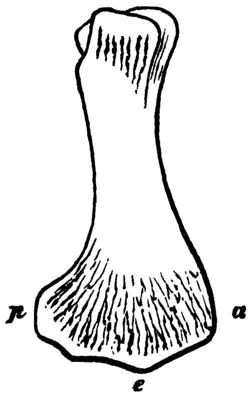


FIG. 2.—Dorsal aspect of the right humerus of *Plesiosaurus trochanterius*; from the Kimeridge Clay, $\frac{1}{10}$. *a*, preaxial, *p*, postaxial border; *e*, division between radial and ulnar facets. (After Phillips.)

Reference was also made to *P. megadirus*, which was considered to be closely allied, although it was stated that in the opinion of Mr. W. Davies it was not identical. It should be added that Mr. Hulke's types are preserved in the British Museum. The year 1871 saw the publication of Phillips's "Geology of Oxford," in which work vertebræ of large Plesiosaurs from the Kimeridgian of Oxfordshire were described under the names of *P. brachyspondylus* and *P. validus*; the former being wrongly identified with *P. brachyspondylus* of Owen, which is really a Pliosaur, and the latter being regarded as new. No reference (perhaps owing to the close sequence of the two works) was, however, made to Mr. Hulke's *P. Manseli*; and detached

propodials were described under the name of *P. trochanterius*. *P. brachyspondylus* was regarded as the Kimeridgian analogue of *P. Oxoniensis*; the vertebræ having the same short and distinctly cupped centra, which characterize both that species and *P. Manseli*. It should also be observed that Phillips described another large Kimeridgian Plesiosaur, which had flattened terminal faces to the centra, and is closely allied to *P. plicatus*, which belongs to a totally different subgroup. Thus matters stood till 1874, when in vol. xxx. of the Q.J.G.S., Professor Seeley figured on p. 447 the above-mentioned pectoral girdle from Ely, under the new generic title of *Colymbosaurus*; stating on p. 445 that the type species was to be *P. megadirus*, which, as already stated, had never been sufficiently described. It was also mentioned on p. 448 that *Plesiosaurus Manseli* was to be referred to a subgenus of *Murænosaurus*.

With these facts we may proceed to criticism. In the first place I cannot find any characters by which *P. Manseli* can be distinguished from *P. trochanterius*, and since the description of the latter is sufficient, I consider that we should adopt the earlier name. *P. brachistospondylus* appears, moreover, to be founded upon dorsal vertebræ of the same species which have been subjected to a strong crush in the axial direction. I have compared the vertebræ figured by Phillips under the name of *P. brachyspondylus*, and also the types of his *P. validus*, with the corresponding vertebræ of the column described by Mr. Hulke, and find an absolute identity between the two; the difference on which Phillips separated *P. validus* from *P. brachyspondylus* being merely due to the different serial position of the vertebræ, and to an erroneous restoration of the neural arch. With regard to the type skeleton of *P. megadirus*, Prof. Hughes has been good enough to send some of the cervical vertebræ to London, and from comparing these, and from a personal examination of the rest of the skeleton two days after having carefully examined that of the so-called *P. Manseli*, I am fully and absolutely convinced of the specific identity of the two. This is also borne out by all the detached vertebræ of this type from the Cambridgeshire district in the British Museum, which cannot be distinguished from those of the latter. Further evidence is afforded by the above-mentioned paddle in the Cambridge Museum, and by another in the collection of Mr. Fisher, in both of which the propodial is of the *P. trochanterius* type.

Now comes the question of the pectoral girdle on which *Colymbosaurus* was founded. As this was referred definitely by its describer to the so-called *P. megadirus*, I had imagined that it was associated with vertebræ of the same type as those of the latter; but my astonishment on arriving at Ely was considerable on hearing from Mr. Fisher that it was an entirely isolated specimen. Although I think it most probable that this specimen is referable to the present form—that is, *P. trochanterius*—yet Prof. Seeley, on the supposition that these two forms were distinct, had no more grounds for referring it to *P. megadirus* rather than to *P. Manseli*, unless he assumed that all the Cambridgeshire specimens belonged to the former and all the Dorsetshire to the latter. Even then, however, there was also the

possibility of this specimen belonging to the large form allied to *P. plicatus* (for which I propose to adopt Owen's name *P. truncatus*), of which there are vertebræ from Ely in the British Museum.

So far, therefore, as I can see, the forms described under the names of *P. trochanterius*, *P. megadirus*, *P. brachistospondylus*, *P. Manseli*, *P. brachyspondylus* (Phillips), and *P. validus*, belong to one and the same species. On the evidence of a detached pectoral girdle Prof. Seeley has, however, made *P. megadirus* the type of the genus *Colymbosaurus*, while *P. Manseli* is referred to a second genus, *Murænosaurus*, apparently on the evidence of the broken coracoids of the type specimen. I think it very probable, as already said, that the pectoral girdle in question does belong to the present species; and I believe, moreover, that the pectoral girdle of the type specimen of *P. Manseli* when complete was (as Mr. Hulke states on p. 59 of the "Proc. Geol. Soc." for 1883) of precisely the same general form; this form having apparently obtained in all the Upper and Middle Jurassic Plesiosaurs.

As a climax to the treatment to which Plesiosaurs have been subjected we may notice Prof. Cope's restoration of the so-called *Elasmosaurus platyurus*, given in the "Trans. Amer. Phil. Soc." vol. xiv. pt. i. pl. ii. In this instance the head has been placed at the extremity of the tail; and the Professor is consequently led to remark in his description that in the vertebræ the prezygapophyses present the unheard-of peculiarity of looking downwards instead of upwards, while the so-called cervicals are indistinguishable from the caudals of other forms.

Finally, after long consideration I have come to the conclusion that it will be convenient to separate from *Plesiosaurus* all those supra-Liassic species having single costal facets and a pectoral girdle without omosternum and the coracoids united by a median bar with the precoracoids. For these forms I propose to adopt the name *Cimoliosaurus*. Leidy, as being the earliest of the numerous terms which have been applied to this group. The typical forms have flattened terminal faces to the vertebræ; but I do not propose to generically separate these forms like *Plesiosaurus trochanterius* and *P. Oxoniensis* in which these faces are cupped; although if such separation should be found advisable, I believe the term *Polycotylus* of Cope is the one which should be adopted. I shall show on another occasion that *Elasmosaurus* of Cope is not separable from *Cimoliosaurus*.

V.—Outcrops.

By W. W. Watts, M.A., F.G.S.,

Fellow of Sidney College, Cambridge, and sometime Deputy-Professor of Geology at Oxford.

NOW that mapping constitutes such an essential part of field-work, it may be of use to some of your readers to connect together a few rules which have occurred to me on this subject.

Valley-Outcrops.—Professor Green has devised an admirably common sense method by which the outcrop of a flat rock-bed can be

traced by means of contour lines. The main results gained from this method may be thus summed up:—

1. A bed of rock parallel with the waterway of a valley crops out in two parallel lines. If the plane be turned through 180°, the lines begin to meet (*a*) *down* the valley where the inclination is in the same direction as, and greater than, that of the waterway; in every other case (*b*), they meet *up* the valley.

2. Where the strike crosses the waterway obliquely, the sharpest change in the outcrop line will be on that side of the valley where the acute angle made by the strike with the contour lines is *smallest* in case (*a*), and greatest in case (*b*).

FIG. 1.

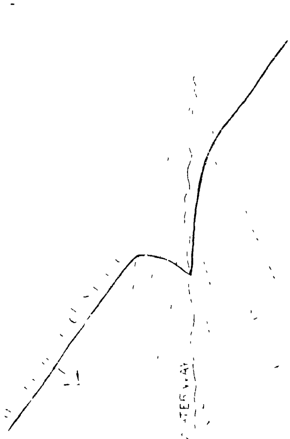


FIG. 2.

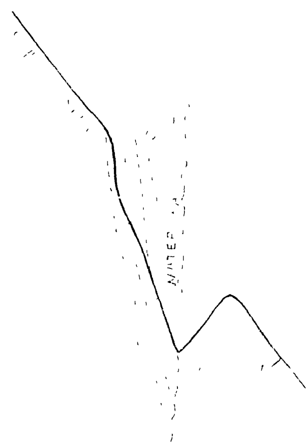


FIG. 1. Outcrop in valley; strike oblique; dip with waterway.
FIG. 2. Ditto ,, ,, ; dip against waterway.

Strike-faults.—Sometimes one is apt to think that the whole nomenclature of faults is unsatisfactory, and some of the terms used, *hade* particularly, misleading. But a little careful consideration will convince us that it is quite right to refer the inclination of hade to a vertical plane and not to one at right angles to the strata; for the two forces responsible for the results of faults are gravitation and crust-crushing, and these two forces together determine the direction of movement. After drawing all the possible cases of strike faulting it is clear that all normal faults, as ordinarily defined, are due to movement under the influence of gravitation where rocks have been *stretched* and cracked, and have moved so as to *gain* space. Reversed faults, on the other hand, are those in which *compression* has occurred and space has been *saved.*

The result is that all normal faults, with one exceptional type, tend to *repeat* the outcrop of beds, while reversed faults, with a parallel exception, have a tendency to *conceal* beds. As the exceptions belong to types of frequent occurrence, Figs. 3 and 4 illus-

trate them, and it will be observed that in both cases the hade of the fault is in the *same* direction as the dip, but at a *greater* angle than it. To contrast with these figures I have chosen two other faults for Figs. 5 and 6, each belonging to one of the other two types.

Fig. 3.

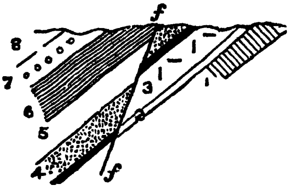
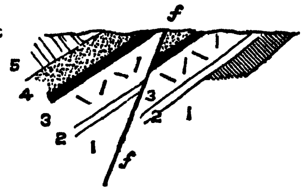


Fig. 4.



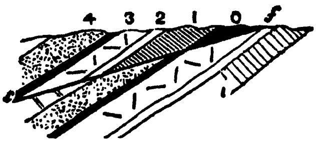


Fig. 5.

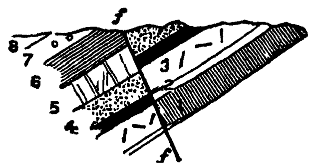


Fig. 6.

Fig. 3.—Normal fault, concealing bed 5.
Fig. 4.—Reversed fault repeating beds 3—4.
Fig. 5.—Normal fault repeating beds 0—1.
Fig. 6.—Reversed fault, concealing bed 5.

Additional complexities will of course be introduced if faults have a hade lower than the angle of ground slope; but I prefer to leave each such case to be dealt with on its own merits.

Dip-faults.—The result of a number of drawings of faults shows that the following law exists. The outcrop on the upthrow side is pushed *forward* in the direction of *dip*, unless the angle of the latter is less than that of the ground slope, when the reverse occurs. Good figures will be found in the manuals by Professors Green and J. Geikie.

Connecting together the exceptions in all these cases, we find they occur—when the strata dip at (1) a *less* angle than (*a*) the *ground* in a *dip* fault, (*b*) the *hade* in a *strike* fault, and (2) at a *greater* angle than the ground in the *valley* outcrop.

VI.—On a Portion of the Osborne Beds of the Isle of Wight, and on some Remarkable Organic Remains recently discovered therein.

By G. W. Colenutt, Esq.

At several places along the north-eastern coast of the Isle of Wight the Osborne Beds crop out on the shore to some extent and admit of examination. From the great difficulty which is usually experienced by geologists in getting at any workable section or outcrop of these beds but little, one might say almost nothing, is known about them. There are few divisions of the Tertiary strata of the Island which present so many variations both of composition

and of fossil contents as do the Osborne Beds at their various outcrops; and at the three places where they are most usually examined —at Whitecliff Bay, at St. Helen's, and at Alum Bay—they yield few fossils, and there is nothing extraordinary about the composition of the clayey strata. On the contrary, at several places between St. Helen's and Osborne these beds crop out from underneath the overlying Bembridge Limestone at places which might easily be overlooked, and present very remarkable features both as to their composition and as to the fossils which they contain. Some description of these strata, and of the organic remains contained in them, may be of interest, as so little is known of them; and the more so as it has been my good fortune to discover in some of the clays organic remains which there is reason to believe are quite new, if not to science, at least to our English strata.

The Osborne Beds in the East Medina may be examined on the shore at several places, more especially below Chapelcorner Copse, between King's Quay and Wootton Creek: just to the west of the boathouse on the shore below Binstead House: on the shore below Ryde House: and immediately to the south-east of Sea View Pier. At all these places the most interesting clays are exposed not in the cliff, but on the beach itself; consequently the strata are not very often seen, being usually covered up and hidden by the shingle and sand of the beach, and more especially so at the last three of the above-named places. At Chapelcorner Copse, on the contrary, the section is generally fairly well exposed, as there is comparatively but little shingle and sand to the west of Wootton Creek; and, as they are practically identical, it will be well to take the strata here as representative of those at the other localities.

It is very difficult to get exact measurements on account of the cliff for some distance inland being covered by a sliding talus of grey and yellow clays thickly covered with underwood. The Bembridge Limestone will, however, be observed in the top part of the cliff and under this we find the following approximate section:—

		Ft.
	(In the cliff.)	
1.	Marls and yellow-grey and dark red and mottled clays	about 40
	(On the beach.)	
2.	Grey clay with scattered fish bones, scales, etc.	,, 4
3.	Hard blue and grey shaly clay with small perfect fossil fish	,, 2
4.	Hard grey clay with matted masses of leaves and lenticular masses of cement-stone	,, 3
5.	Blue clay with many seams of crushed *Paludina lenta* and *Melanopsis carinata*	,, 6
6.	Unfossiliferous soft green clays extending to low-water mark.	

The clays numbered 2, 3, 4, and 5 in the above section are the most important, and afford valuable information as to the flora and fauna which flourished when they were deposited.

In number 2 thin lenticular masses of crushed fish bones occur, with many ganoid scales and fish vertebræ (*Lepidosteus*): teeth, bones, and dermal plates of *Alligator Hantoniensis* (?): bones and plates of *Emys*, *Trionyx*, and *Chelone*: incisor and molar teeth and

bones of a small rodent (*Theridomys*) [rare]: a small snake vertebra was found among the crushed bones and also a jaw of *Lepidosteus* (?).

In number 3 the most remarkable fossils are found in a hard, dark grey laminated clay, and consist of small exquisitely perfect teleostean fish, varying in length from three-quarters of an inch to three inches: also bones, scales, and vertebræ of larger fish: crustaceans apparently allied to the shrimp or prawn and measuring from half an inch to two and a half inches in length [rare]: *Cyprides*: occasional masses of crushed *Paludina lenta* and *Melanopsis carinata*: a few scattered ganoid scales: and spines and bones of larger fish.

In number 4 seams of compressed vegetable remains occur: a few leaflets of ferns [rare]: small carbonized seed vessels, with longitudinal striations (not yet identified): a few small twigs of a Conifer: occasional masses of lignite: and detached fragments of turtle plates.

In number 5 *Paludina lenta* and *Melanopsis carinata* occur abundantly in thin seams, but they are mostly in a crushed state. No other species of Mollusca have been observed. Vertebræ of large fish occur, especially in a thin seam of finely comminuted shells at the base of this division: teeth apparently of *Alligator Hantoniensis* are found in this division, but they are rare here; a few detached turtle plates are found, but they are not so often met with here as in the clay a little higher up.

In number 6 and in number 1 I have not been able to discover the existence of any organic remains at all.

The strata have a very slight dip of about 5° or 6° to the south; but this dip, close to the base of the cliff, is much increased—caused no doubt by the weight of the talus, which in wet weather is in a very soft and oozy state, and is always on the move down towards the shore.

The beds above described occupy about the middle of the Osborne series, but the dark clay in which the small perfect fish occur is no doubt a local deposit, although it occurs at Binstead House, Ryde House, and at Sea View, as well as at Chapelcorner Copse. The distance is about 5¼ miles, as the crow flies, between the furthest outcrop of the fish clay to the west (at Chapelcorner Copse), and the furthest outcrop to the east (on the shore in the angle formed by the sea-wall immediately to the south-east of Sea View pier). Thus it will be seen that the deposit is of considerable extent, although it is no doubt correctly considered as local.

Although I have at every opportunity made a most careful search, I have never been able to discover the presence of this clay at any of the other places in the island where the Osborne Beds are exposed. At Whitecliff Bay, where the Osborne Series is visible in its entirety, I have been unable to find any trace of the fish clay; neither have I at Gurnard Bay, nor at any of the other sections in the West Medina. The shore sections between Ryde and Sea View are much obscured by the sea-wall which runs the entire distance, thus preventing any examination of the clays which would crop out along the beach and low cliffs.

The small fossil fish from division 3 are most beautifully pre-

served—even the minute rays of the fins and tails being most clearly defined. From the fact that the fish are largely impregnated with iron pyrites, they present a beautiful golden appearance, especially when first exhumed from the clay. The head is not, as a rule, so well defined as the other portions of the body, yet it is very often possible to see the eye preserved as a black spot, and the discolouration of the intestines is sometimes seen in the specimens. It is not usual to meet with one fish alone, but they generally occur in small shoals—the remains of no less than *nine* separate and distinct fish being imbedded in a small slab of clay measuring two and a quarter inches square, which I have in my cabinet. This, however, is an exceptionally good shoal. A good deal of iron pyrites occurs in the clay in small soft, gritty, dark-grey masses, and some of the larger specimens of the fish are much disfigured and spoilt by the iron pyrites with which they are encrusted, and into which they are transformed. In several other divisions of the clay we find iron pyrites matting the shells together into thin slabs, and occurring as irregular brown masses in the clays.

It is always very interesting to endeavour to ascertain from the evidences presented, the origin and mode of formation of a local or accidental deposit like the fish clay, and to arrive approximately at some idea of the state of things both before and after the occurrence happened which gave rise to the deposit.

In the clays underneath the fish clay we find evidences of the existence of a comparatively tranquil lake or river inhabited by *Paludina*, *Melanopsis*, *Cypris*, *Trionyx*, and other similar forms. The flora is represented by crushed masses of vegetable remains and by plants of which we find the seeds (not yet identified). A few ferns existed on the land, but the remains of these are very rare, as also are the few remains of conifers. That the area of deposit was but little disturbed is evident from the perfect condition in which the vegetable remains are preserved, for they show no signs at all of having been subjected to attrition. But a change took place in the form of a sudden influx of mud and foreign matter. It remains to be seen from careful and expert examination whether the fish which we find in this clay may be assigned to any genus of fish inhabiting the sea, or whether they are clearly of freshwater origin; and very considerable interest attaches to the solution of this question. That the fish were smothered by the mud is perfectly clear, for the result even of a day's decay would be to damage and spoil the delicate bones of the fins and tails. Then again, these fish are found entombed in a perfect state in small shoals, which would not be the case had they died a natural death and been drifted together—they would be more or less damaged by the drifting process. And I have never found vegetable or any other remains mixed up with the fish—which one would expect to do in the case of drifted exuviæ. In several cases the fish have been compressed flat without being laid on their sides, and in these cases we see the fish from above and do not see the dorsal fin at all, but both eyes are visible in the form of two black spots, one on either side of the head. Masses of commi-

nuted bones of larger fish do occur, but not on the exact horizon occupied by the small perfect fish—they are either just above or just below. The shrimps or prawns, which are found on precisely the same horizon as the perfect fish, are too in a very perfect state, and this is another fact in support of death by smothering. It seems doubtful whether such crustaceans as these—the largest I have measures about two and a half inches in length—were inhabitants of freshwater, but rather were drifted into the river or lake from the sea with the mud (and possibly with the small fish) and there entombed alive. Again, the texture of this fish clay is quite different from anything above or below it—indeed it is quite different from any of the Tertiary clay of the Island—being shaly and readily splitting into layers. It has also a well-defined transverse jointing, and this property is the cause of its easily dividing into irregular masses, in which state it is often rolled about by the waves and water-worn into rounded nodules. There is one very thin seam of *Paludina* and *Melanopsis* forming the top layer of the fish clay, as though after the fish clay had been deposited, the freshwater inhabitants had all been killed also by the influx of salt water or other agency; in the clay above no remains of mollusca are found at all. The whole scheme of life seems to have changed and the only organic remains are those of large fish and reptiles with the bones of a few small mammals. Above the horizon of these seams of fish bones we find nothing but grey and yellowish and red mottled unfossiliferous clays of varying hardness, which seem to point to water—probably of a brackish nature—but with an almost total absence of the usual freshwater life.

Above these beds of clay comes the Bembridge Limestone showing the reverting to purely freshwater conditions, and the consequent recurrence of a freshwater fauna.

The small fish and the shrimps were first discovered in the year 1876, at Ryde House, and since that time I have, from the several localities, obtained about one hundred and fifty specimens of the former and about twelve specimens of the latter.

[N.B.—Mr. E. T. Newton, F.G.S., of the Museum of Geology, Jermyn Street, is examining and naming the fish and Crustaceans mentioned in this paper, and his description of them will appear in due course.]

VII.—On *Hindeastræa*, a New Generic Form of Cretaceous Astræidæ.

By Dr. Charles A. White.
Palæontologist, U.S. Geological Survey.

THE little Coral here described was discovered in Kaufman County, Texas, in strata of the Ripley Group, by Dr. R. H. Loughridge, and presented by him to me, together with a few characteristic molluscan species of that group which he found associated with it. The Ripley Group is the uppermost division of the Cretaceous series in the States which border upon the Gulf of

Mexico; and probably represents approximately the Upper Chalk of England. Regarding it as a new generic form I herewith give a diagnosis and figures of it; and being the only species known to me, the diagnosis is necessarily based upon this alone.

HINDEASTRÆA, gen. nov.

Corallum depressed or discoid, simple in the earlier stages of growth, but afterward becoming compound by gemmation; basal epitheca marked by both radiating striæ and concentric rugæ: corallites few, without true columella, their outer walls fused together when in contact, and moderately strong; radiating septa bilaminate, subequal in thickness at their peripheral ends, consisting of three or four cycles as regards their length, subspinulose, tuberculose, or rugose upon their sides and upon their free upper edges; dissepiments few or absent.

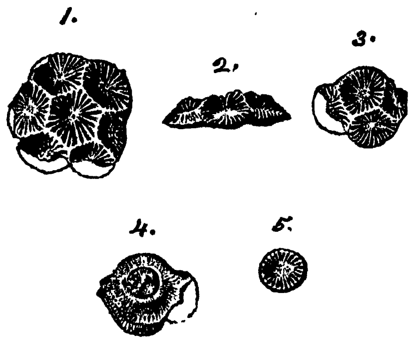


Fig. 1. Calicular view of the largest example discovered.
Fig. 2. Lateral view of the same.
Fig. 3. Calicular view of a medium sized example.
Fig. 4. Under view of the same, showing the basal epitheca.
Fig. 5. Calicular view of a corallite upon which no gemmation has occurred. All the figures are of natural size.

This genus is related to *Isastræa*, E. and H., but it differs from the latter in its mode of growth, *Isastræa* being massive, and the dissepiments of its corallites being usually numerous and well developed. The extreme shortness of the axis of the corallites of *Hindeastræa* gives little or no space for the development of dissepiments. The walls of the corallites also form more distinct boundaries between the calices than is usual in *Isastræa*.

The generic name is given in honour of Dr. G. Jennings Hinde.

HINDEASTRÆA DISCOIDEA, sp. nov.

Corallum irregularly discoid or much depressed, attached by the apex of the original corallite, or free; corallites few, very short but moderately broad; the walls of the adjacent corallites usually in contact and fused together, when the border is polygonal; but they sometimes have a tendency to separate, when the border is subcircular; calices slightly concave or nearly flat; their borders more or less prominent and clearly defined; radiating septa prominent,

22 to 26, usually 24, in number; those of the first cycle four to six in number, reaching nearly or quite to the centre of the corallite, where they are more or less contorted. Those of the second cycle do not usually terminate interiorly by free ends, but are there joined to one another or to those of the first cycle. Those of the third cycle usually terminate like those of the second, but are sometimes free at the inner end; the sides and free edges of the septa subspinulose or tuberculose. The number of corallites in a corallum varies from one to seven or eight, their gemmation taking place at the margin of the calice, and usually after the original corallite had attained considerable size.

Diameter of the largest calice observed, 8 millimeters.

The type specimens [1] are preserved in the U. S. National Museum, at Washington.

WASHINGTON, *June 12th*, 1888.

NOTICES OF MEMOIRS.

I.—"SUR LES TÉLÉOSTÉENS DU RUPÉLIEN." By L. DOLLO and R. STORMS. (Zool. Anzeiger, No. 279, 1888.)

MESSRS. DOLLO and STORMS have undertaken the investigation of the Fossil Fishes of the Mesozoic and Tertiary deposits of Belgium, and we are glad to welcome the first brief instalment of the results of their joint researches. The present note deals with the systematic position and nomenclature of the genera *Sphyrænodus*, Agassiz, and *Scomberodon*, P. J. van Beneden. *Dictyodus*, Owen, is adopted as the correct name for the so-called *Sphyrænodus*, and the fish is referred to the Scombridæ, on account of the characters of its dentition, premaxilla, palatine, mandible, and the caudal region of the vertebral column. It is respectively separated from *Cybium* and *Pelamys*, its nearest allies, by its single series of large conical palatine teeth, and by the greater strength of its dentition and premaxilla. *Scomberodon* is considered to be identical with *Cybium*, and the type must henceforth be known as *Cybium Dumonti*.

A. S. W.

II.—PROF. DR. W. DAMES ON *GIGANTICHTHYS PHARAO*. (Sitzungsb. Ges. naturf. Freunde Berlin, 1887, p. 137.)

THE generic name *Titanichthys* being preoccupied, Prof. Dames suggests that of *Gigantichthys* for the large Cretaceous fish-teeth from Egypt, already described under the name of *Titanichthys pharao* (see GEOL. MAG. for April, 1888, p. 157).

[1] Specimens of this Coral have been presented to the British Natural History Museum through Dr. G. J. Hinde.

REVIEWS.

I.—British Petrography, with Special Reference to the Igneous Rocks. By J. J. Harris Teall, M.A., F.G.S. (London, Dulau & Co., 1888.) Royal octavo, pp. 470, with 47 Chromo-lithographic Plates.

FOR some years students have been longing for a well-illustrated and comprehensive work on the mineral structure of rocks. Memoirs on certain parts of the subject, such as Wadsworth's Lithological Studies, or Zirkel's Microscopical Petrography, were accessible without much difficulty; there was the Minéralogie Micrographique of MM. Fouqué and Lévy, with its splendid illustrations, but this is written too much from the mineralogical point of view for the ordinary student, and Professor Rosenbusch's "Mikroscopische Physiographie der massigen Gesteine," though a treasure house of erudition, is vitiated by a faulty principle of classification, and is almost without illustrations. Moreover, it is not every student who can read French or German with as much facility as English. We have now a book in our own language which is comparable in its illustrations with that of Fouqué and Lévy, and in its erudition with the treatise of Rosenbusch. True, it deals only with British rocks, but these are so comprehensive, that there is comparatively little wanting to make it a complete work of reference so far as those of igneous origin are concerned.

The work is illustrated by several woodcuts interspersed in the text and by 47 coloured plates—the former occasionally leave something to be desired in clearness, but the latter as a rule are excellent, and are accompanied by outline key-plates. The examples on the whole appear to be very judiciously selected. The task before Mr. Teall was not quite so difficult as the proverbial decanting the Ocean into a pint pot; but still the plethora of wealth must have caused him no little embarrassment. If we were disposed to take exceptions, we should say that a little too much favour had been shown to the more basic rocks, though in these we still desiderate a tachylite, and to the pyroxenic group of minerals, and that the selection of the non-igneous rocks, necessarily a very restricted one, was not in every case the best possible. Of the 47 plates, rather more than eight are devoted to the peridotites, picrites, and serpentines, and it takes full thirty plates to get clear of the more basic half of the igneous rocks. Thus, the more acid group—granites, quartziferous felstones, pitchstones, and kindred rocks—seem to us rather inadequately represented. It is, no doubt, difficult among so many excellent figures to suggest excision, but we doubt whether two are needed in the case of quartzite, and whether the student will learn much from that of a crushed quartzite. Indeed, either the figure is not very successful, or the rock prior to its deformation was not very like the normal quartzite represented in the upper part of the plate, but must have been a much "dirtier" example. Again, the deformed volcanic breccia in plate xlv. should have been placed side by side with a normal specimen. Indeed, throughout the book

we think the author leans a little too much upon dynamic metamorphism, real or supposed. Thus, there is only one figure illustrating contact metamorphism in a sedimentary rock, and that is the somewhat abnormal case of the chiastolite slate of Skiddaw. We should have gladly seen with it an example of the mica-andalusite rock which occurs in the same region nearer to the intrusive granite. But when one remembers the exceptional difficulties under which Mr. Teall has accomplished his task—for the failure of the first publisher threatened to shipwreck the book, at a comparatively early stage of its issue, and the author has completed it, at his own risk, without any hope of profit, and with more than a possibility of loss—it seems ungenerous to cavil at minor blemishes, for the book now comes almost as "a gift-horse."

So we will allow ourselves but one other criticism. The title of the work does the author an injustice—it is not a *Petrography*, but a *Petrology*. No doubt, as he says, the work is to a large extent devoted to a description of the rocks so far as this is dependent on the examination of hand specimens; but the significance of the structures and of the relations of the minerals are again and again discussed; indeed, the chapters on the characters and classification of igneous rocks, on their origin, metamorphosis, and destruction, are of the highest value. We lay some stress on this verbal question, because the confusion between the two terms Petrography and Petrology is so common, especially among continental writers. Perhaps the author would thus defend his selection of a title; but we have yet to learn that "following the multitude to do evil" is a valid excuse in science any more than in ethics. The distinction between a "graphy" and a "logy" is indisputable, for it rests on the inherent significance of words—and no concurrence of authors, however eminent in science, can alter this. The "petrographer" must be content to walk with the geographer and shake hands with the photographer; to receive only a bow of condescension from the mineralogist and the geologist.

The dominant principle of Mr. Teall's work we believe to be a thoroughly sound one. It is, that to give an accurate description of a rock is a vastly more important matter than to give it a name. A rock type is to be regarded as the 'locus' in which a group of characteristics meets, as a convenient expression of a complex idea, rather than as a distinct entity. Hence, though we are obliged to name, and are bound to define with some precision, our ideal types, though it is unpardonable to misapply their names—as, for instance, to call a rock a serpentine when it contains much silicate of alumina and comparatively little silicate of magnesia—still our species, as we may call them, should be made as inclusive as possible, and precision should be obtained rather by addition of epithets than by novelty in nomenclature.

The first chapter of the book gives an admirably clear sketch of the constituents of igneous rocks, describing their various forms, microlithic and otherwise, together with an outline of the work which has been done in the study of inclusions in minerals and the

significance attached to them by various workers. Succeeding chapters summarize the chemical and physical characters of igneous rocks, giving a brief notice of the uses made of certain chemical solutions in separating rock constituents, and determining their specific gravity. Indeed, we may say that in every part Mr. Teall appears to have brought up his information to the latest date, though he wisely abstains from burdening his book with long descriptions of methods of investigation, chemical or physical. Next comes the classification of igneous rocks, where the principle already noticed is enunciated. The author also discusses the vexed question of geological age as a primary factor in classification of igneous rocks. Here British petrologists have for some years been at issue with most of their fellow-workers on the Continent. Of the ultimate result of the contest there can now be little doubt. Mr. Teall takes this position, "While declining to accept geological age as a primary factor in classification, . . . the present writer is strongly of opinion that, if possible, it should receive indirect expression. . . . So when any peculiarity of texture or composition can be shown to characterize rocks of a particular period, that peculiarity should be utilized for purposes of classification." To this concession no reasonable objection can, in our opinion, be made: probably, however, it will be rarely of avail in practice. The succeeding chapters describe the more important varieties of igneous rocks. This portion of the book will be found by the student a perfect mine of valuable information very lucidly arranged. Mr. Teall has mastered the voluminous literature of the subject, and gives an admirable summary of the result of his studies. His unwearied patience and assiduity will cause future workers to invoke blessings on his name, and to save them from being crushed, to use Professor Huxley's metaphor, beneath the gifts which have been heaped upon them; gifts, among which, as in the case of Tarpeia, there is much metal of greater weight than worth, as well as the gold. This sketch is to a certain extent critical as well as historical, as it should be, but it is executed, as a rule, in a thoroughly judicial spirit. If the author shows any bias, it is in an occasional disposition to regard dynamic metamorphism too much as an established theory rather than a probable hypothesis. Perhaps also it would have been well to have mentioned that in some cases where foliation is claimed as the result of regional or dynamic metamorphism, difficulties have been indicated and other hypotheses suggested. Still, this potent factor of change has been so overlooked of late years, that we are glad to see the student's attention called to it, It must hold a prominent place in future among the agencies of metamorphism, though we doubt whether *Ecpiesis* will ultimately enjoy a supremacy quite as universal as seems at present to be claimed by some of her newly-converted devotees!

Under each principal group the author describes the different examples and varieties of igneous rocks, according to their geographical distribution, thus adding to the utility of his book as a work of reference. There is a particularly valuable sketch of the

'Mica Traps.' The nepheline rocks of course can only be illustrated by the well-known example from the Wolf Rock, and for a leucite rock the author has had to go beyond the limits of the British Isles. Here we think a better example might have been found for figuring than that which he has selected. The principal types, however, are all briefly described in the text. There is an excellent chapter on Contact Metamorphism, and that which follows, on the origin of Igneous rocks, is one of the most valuable in the book; for it contains a discussion of the experiments by the late lamented Prof. Guthrie, on eutectic solutions, and of the no less important researches of Lagorio on the crystallization of minerals out of igneous magmas. The work concludes with a discussion of the metamorphoses and destruction of Igneous rocks, which is to some extent a summary of questions touched upon in the body of the work. Dr. Hatch has contributed a glossary of terms used in describing rocks, for which also the student should be duly grateful, as its compilation must have cost much labour of a rather dull kind.

We have not attempted to give a full summary of this admirable work. Its 422 large octavo pages are so replete with valuable matter, that this would be impossible, and we have no disposition to save the student from the labour, no less profitable than pleasant, of reading the book. It is one which every geologist who desires accurate information on the structure of our igneous rocks should have upon his shelves. We have frankly ventured one or two small criticisms, but we wish it to be understood that these relate in the main to questions where, doubtless, the personal equation come in, with the reviewer as well as with the author—and conclude by no less frankly asserting that it bears on every page testimony of the most conscientious labour, and is not only a careful compilation, but also full of the results of original research. Knowing well Mr. Teall's abilities and learning, we had expected much, but we have found more. Henceforth he will hold a place in the foremost rank not only of petrographers but also of petrologists. T. G. B.

II.—Report on a Part of Northern Alberta, and Portions of Adjacent Districts of Assiniboia and Saskatchewan. By J. B. Tyrrell, B.A., F.G.S.; pp 1 E to 176 E, with Appendices i—iv and two Maps. (Geological and Natural History Survey of Canada, Part E, Annual Report for 1886; Montreal, 1887.)

IN this report Mr Tyrrell furnishes us with an account of the geology and natural resources of the tract surveyed and points out the "extent, position and character" of its mineral deposits. The country traversed "lies between the 51st and 54th parallels of North latitude, from longitude 110° to 115° 15′ west, including an area of over 45,000 square miles." The author begins (p. 7 E) with a brief history of former explorations, among which the most important of the earlier ones was that carried out by Captain Palliser, with Dr. Hector as Geologist (1857-1859). These pioneer explorers were followed by many others, some of whom, like Milton and

Cheadle,[1] and W. F. Butler,[2] have made this vast region familiar to many readers by the graphic descriptions they have given of their journeyings through it; while Selwyn (1873), Ells (1875), and G. M. Dawson (1879) have added much to our knowledge of its geology. The physical features of the country are treated of in detail by Mr. Tyrrell (pp. 14 E to 56 E); but we have space only for a very brief extract from this part of his report. We learn that "the general character of the country is that of a sloping plain, breaking into abrupt ridges to the south-west, where a small area of foot-hills is included. From the base of these hills, which attain a height of 5000 feet above sea-level, the country declines to the north-east, sloping off from an altitude of 4000 feet, along the eastern edge of the foot-hills, to 1650 feet at Fort Pitt, on the Saskatchewan. The slope, though fairly regular, taken as a whole, is, however, broken by numerous high hills and deep river channels."

The rock formations dealt with in the report, under the head of "Descriptive Geology" (pp. 56 E to 126 E), are enumerated in the following table in descending order:—

	Feet.
POST-TERTIARY.	
Recent Deposits.—Sands, Clays, etc.	
Upper Boulder Clay.—Light-grey sand, and, generally, indistinctly stratified clay, with pebbles of gneiss, quartzite, etc.	
Lower Boulder Clay.—Dark-grey, thick-bedded, or massive, sandy clays, containing pebbles of quartzite, etc., and numerous fragments of lignite	
Pebble Bed.—Quartzite shingle, lying in a loose sandy matrix	
MIOCENE.	
Gravels, fine sands and argillaceous marls, the gravels sometimes cemented into a hard conglomerate	270
LARAMIE.	
a, *Paskapoo Series.*—Grey and brownish-weathering, lamellar or massive sandstones, and olive sandy shales; an exclusively fresh-water deposit	5700
b, *Edmonton Series.*—Soft whitish sandstones and white or grey, often arenaceous clays, with bands and nodules of clay ironstone, and numerous seams of lignite; a brackish-water deposit	700
FOX HILL AND PIERRE.	
Brownish-weathering sandstones and dark-grey clay-shales	600
BELLY RIVER SERIES.	
Soft, whitish sandstones and arenaceous clays, changing towards the east to light-brownish and yellowish sandstones and sandy shales, bottom not seen.	

"No intrusive rocks occur anywhere throughout the district, and below the top of the Laramie there is no evidence of any unconformity between the different formations. . . ."

Belly River Series.—Owing to the unfossiliferous character of the beds and the scarcity of sections, the exact boundaries of this series could not be accurately defined. The only fossils found were a few fresh-water genera, *Unio*, *Sphærium*, etc., and fragments of the leaves and wood of plants.[3] No workable coal-seams were found.

[1] "The North-West Passage by Land," 1863.
[2] "The Great Lone Land," 1873.
[3] Described by Sir W. Dawson in Trans. Roy. Soc. Canada, 1887, Sect. iv. p. 31.

Fox Hill and *Pierre Group.*—The Fox Hill sandstone and the Pierre shales were found to be so completely interbedded as to make it impossible to separate them, the yellow sandstone at the top of the group being precisely similar to that at the bottom, and holding, moreover, the same fossils, viz. *Placenticeras placenta, Teredo* burrows, etc. A large series of characteristic fossils was obtained, some of them being new to science.[1] No workable beds of coal were found within the district surveyed.

Edmonton Series.—This is regarded as the most characteristic series of the whole region, "for though its thickness, wherever determinable, was never found to exceed 700 feet, the horizontal position of the strata causes it to underlie a very large extent of country" from the outcrop of the "Big Coal Seam," on the North Saskatchewan, "to or a little beyond its easterly bend north of the Beaver Hills; and stretching a little south of east to Red Deer River in the vicinity of the Hand Hills, comprising the lower part of the bold escarpment, which there forms the south-western boundary of these hills." Extensive Coal-beds were found on this horizon, which, commencing as a "thin bed of carbonaceous shale, attained on the North Saskatchewan a thickness of 25 feet. Gold was found in paying quantities disseminated through the rocks in the vicinity of the "Big Coal Seam" on the North Saskatchewan. It is washed out of the sandstone and clays, and "settles with the heavier sand and gravel on the bars running out into the stream." Regarding the derivation of the gold in the Saskatchewan, it has been held[2] by Dr. Selwyn that it was not derived from the mountains at the source of that river, "but rather was washed out of the soft rocks which form its banks, after it leaves the harder strata of the mountains. . . ." (p. 134 E.)

The bottom of the Edmonton Series rests conformably upon the Pierre Shales, "without any sharp line of demarcation between the two," the shales gradually losing their massive character, and changing insensibly into thin beds, of brackish-water origin. Whereas in the Pierre group remains of land plants and animals were of rare occurrence, traces of land plants and fragments of the teeth and bones of Dinosaurs were met with in considerable abundance in the series under discussion. The last-named fossils were submitted to Professor Cope for determination. The rest of the fossils included Molluscs of the genera *Ostrea, Unio, Corbicula,* and *Panopea,* and plants consisting of *Trapa, Salisburia,* and *Carpolithes,* together with fragments of exogenous leaves and wood of *Sequoia* and *Thuja.*

Paskapoo Series.[3]—The author thus designates "all the Laramie rocks lying above those of the Edmonton series," and he therefore includes Dr. G. M. Dawson's "Porcupine Hills and Willow Creek series, and all but the lowest 700—900 feet of his St. Mary River

[1] These are described by J. F. Whiteaves in Appendix I. of the Report, p. 153 E.

[2] See Geol. Surv. Rep. for 1873-74, p. 58 (Montreal).

[3] From the "Blind Man," or "Paskapoo" River, which flows into the Red Deer River from the north-west, over rocks of the Paskapoo or upper subdivision of the Laramie.

series." Its thickness on Little Red Deer River was ascertained to be at least 5700 feet, "the bottom of the formation not being seen, and a considerable thickness having been probably removed from the top by denudation. The whole series was proved by its fossil fauna to be of freshwater origin, shells of the genera *Unio, Sphærium. Limnæa, Physa, Goniobasis*, etc., attesting this fact. Fossil plants of the genera *Sequoia, Taxodium, Platanus, Quercus, Populus, Salix, Viburnum*, etc., were also collected.

It will be observed in the table of strata above, that the Edmonton and the Paskapoo series are given as subdivisions of the Laramie, the former representing the Lower Laramie of the Canadian Geological surveyors, and the latter the Upper. The physical conditions under which these two series were deposited are thus described:— In the Edmonton series, which succeeds the marine beds of the Upper Cretaceous, Mr. Tyrrell finds abundant evidence of the brackish-water origin of this series, in the presence of beds of coal, fragments of land plants, and brackish water molluscs, besides numerous bones of Dinosaurs, "which have evidently been entombed in the beds over which they waded, or in the marsh on or along the edge of which they used to feed, or hunt their prey." He concludes, therefore, that this series "was laid down in shallow brackish water in an almost land-locked bay, or in a great salt marsh near the mouth of a large river. . . ."

"At the close of the Edmonton period, the pressure which had caused the uprising of the present plains-area from the bottom of the Pierre sea, and which towards the west had raised the land completely above the surface of the water, was relieved by the uplifting of the Rocky Mountains along a line near the western edge of this great area, and the "plains" sank again beneath the surface of the sea, now cut off entirely from the main ocean, and converted into a great inland lake, and a thickness of several thousand feet of sandstones and sandy shales was laid down on the gradually sinking floor; these sandstones and shales being the Paskapoo series of this report. . ."

No Dinosaurian remains were discovered in these beds, but a number of land plants, land and fresh-water molluscs, with occasional beds of coal occur in them.

The Laramie beds suffered a considerable amount of denudation at the close of their deposition, during a period of elevation which took place before the Miocene beds began to be laid down.

From all these facts Mr. Tyrrell deems himself justified in concluding that the Cretaceous Epoch terminated with the deposition of the uppermost beds of the Edmonton series; and that the Tertiary Epoch began with the commencement of the Paskapoo period, which he regards as "the representative of the Eocene of Europe," an opinion held also by Dr. Newberry.[1]

Concerning the exact age of the Laramie little can be affirmed with certainty. We have seen what Mr. Tyrrell's views are upon the subject; it may be profitable now to consider those of some

[1] Trans. New York Academy, Feb. 1886.

other geologists. The question has been attacked with much ability and mastery of details by Mr. Lester F. Ward, in a "Synopsis of the Flora of the Laramie Group."[1] This writer gives it as his opinion that "it is wholly immaterial whether we call the Laramie Cretaceous or Tertiary, so long as we correctly understand its relations to the beds below and above it. We know that the strata immediately beneath are recognized Upper Cretaceous, and we equally know that the strata above are recognized Lower Tertiary. Whether this great intermediate deposit be known as Cretaceous or Tertiary is therefore merely a question of a name, and its decision one way or another cannot advance our knowledge in the least." Sir William Dawson, in his memoir on the "Fossil Plants of the Laramie Formation of Canada,"[2] concludes "that we must either regard the Laramie as a transition Cretaceo-Eocene group, or must institute our line of separation in the Middle Laramie division, which has, however, as yet afforded no fossil plants."

Miocene.—"Resting on the denuded edges of the Laramie in the Hand Hills, are beds of light-grey argillaceous marls inter-bedded with fine grained sands, which pass upwards into a bed of quartzite pebbles, in some places held together by a hard calcareous cement, and forming a compact conglomerate."

No fossils were found in this formation, but from its position and character it was judged to be of the same age as the Miocene of the Cypress Hills, described by Mr. McConnell in 1884.[3]

Post-Tertiary.—The following are the subdivisions of this formation, distinguished by Dr. G. M. Dawson, which hold good also in the area explored by Mr. Tyrrell:—"Stratified sands, gravels and silts. Upper boulder-clay. Interglacial deposit with peat. Lower boulder-clay. Quartzite shingle and associated beds."

These beds overlie the greater part of the region examined in "an extensive, though generally thin, sheet," filling up the irregularities in the surface of the Cretaceous and Laramie rocks, and forming also many of the rolling hills.

Economic Minerals.—First in importance are the extensive deposits of Coal and Lignite which underlie an area of more than 12,000 square miles in the western part of the district surveyed. Of bituminous coal, a seam near the Bow River is estimated to contain about 9,500,000 tons of coal to the square mile. Of the lignitic or semi-bituminous coals, the seam on the North Saskatchewan River was computed to contain over 150,000,000 tons. The occurrence of Gold in this river has already been noted.

This valuable report closes with four appendices, the first containing descriptions by J. F. Whiteaves of the fossils collected by Mr. Tyrrell (1885 and 1886) in the Cretaceous and Laramie Rocks; the second, "Lists of Lepidoptera," by Mr. James Fletcher; the third, "List of Elevations"; the fourth, "Cree and Stoney Indian names for places within the area of the accompanying map." It

[1] Sixth Annual Rep. of the United States Geol. Surv. 1884—85, Washington, 1885.
[2] Trans. Roy. Soc. Canada, Sect. iv. 1886, p. 19.
[3] Geol. Surv. Rep. Canada, for 1882—84, p. 140 C.

may be added that the maps accompanying the Report are drawn to a scale of seven geographical miles to one inch. One illustrates the geology, the other marks the wooded and prairie tracts of the country embraced in the report. A. H. F.

III.—Dr. Georg Baur on Fossil Chelonia.

THE publication of preliminary notes and synopses of results is often desirable, as affording the opportunity of criticism before the completion of any extensive work; and it is sometimes a convenient method of securing valuable co-operation from other workers in a given field. But when indulged in to so great an extent as is now unfortunately the custom in some quarters, the practice becomes both confusing and annoying; and the steady progress of science degenerates into a mere struggle for "priority," burdened with endless unfinished notes and crude speculations. Such considerations are once more suggested by Dr. Georg Baur's latest remarks upon the Palæontology of the Chelonia. Entombed in the form of a footnote to a four-page pamphlet upon the origin of the paddles of the Ichthyopterygia,[1] is the definition of a supposed new genus of Chelonia from the Keuper Sandstone of Würtemberg! The fact is one of considerable interest, and the fossil of the greatest importance; but the future historian of the Chelonia is hardly to be blamed if he fails to discover the "priority" of the name *Proganochelys Quenstedtii*, when referring to this unique fossil: one author, indeed, in another "preliminary note" upon the same specimen,[2] has already overlooked both the description and the name. The fossil is a natural internal mould of the carapace and plastron of a Chelonian, especially remarkable for its high degree of specialization; and it is not improbable that, when more is known of the animal, it will prove to be identical with *Chelytherium obscurum*, von Meyer. The plastron is described as completely closed, and united laterally with the carapace, without any fontanelles.

The next reference to *Proganochelys* occurs in a letter[3] announcing the discovery of small dermal ossicles upon the limbs of *Testudo Leithii*, where the interest of the genus is remarked upon in connection with the controversy as to the systematic position of the Athecan Chelonia: and then the subject of "Unusual Dermal Ossifications" suddenly develops into the definition of another new genus, founded upon the well-known "*Chelone*" *Hoffmanni* of the Maastricht Chalk. Dr. Baur proposes henceforth to place the latter in a genus named *Allopleuron*, on account of the small development of the costal plates and the narrowness of the marginals. The results are most interesting and worthy of consideration, but it is not too much to ask that in future we may have the subjects under recognizable titles, even if it is still considered desirable to publish them in so obscure and scattered a form. A. S. W.

[1] G. Baur, "Ueber den Ursprung der Extremitäten der Ichthyopterygia," Bericht xx. Versamml. Oberrhein. geol. Vereins, 1887.

[2] Zarszewski, "Eine im Stubensandstein des Keupers gefundene Schildkröte," Württ. Jahresh. 1888, p. 38.

[3] G. Baur, "Unusual Dermal Ossifications," Science, March 23rd, 1888 (vol. xi. p. 144).

IV.—On the Structure and Relations of *Edestus*, with a Description of a Gigantic New Species. By Prof. J. S. Newberry, M.D. (Annals New York Acad. Sci. vol. iv. No. 4 (1888), pp. 1-10, pls. iv.-vi.)

THE discovery of a new gigantic example of the remarkable fossil spine, *Edestus*, in the Coal Measures of Mason County, Illinois, affords Prof. Newberry the opportunity of again reviewing the characters and possible relationships of this anomalous fish-fragment. The memoir is one of much interest, and refers to nearly all the points hitherto ascertained, except Trautschold's discovery of the occurrence of the fossil in Russia. It would, however, have added much to the completeness of the discussion, if a microscopical section had been prepared; for if *Edestus* consists of "dense bone" (p. 5), it is certainly not a Selachian dermal appendage, and if it has the well-known structure of the latter, it is useless to speculate as to its pertaining to a Ganoid (p. 4). From various other considerations, Prof. Newberry concludes that the original fish must have been a Selachian; and the fossil is regarded as an undoubted spine. The latter must have been "buried in the integuments throughout its entire length; the enamelled denticles alone projecting above the surface to form a saw, which would be a terrible weapon, if placed upon some flexible portion of the body where it could be used with freedom and power. The extremity of the spine may have lain in a sheath from which it could be partially erected by muscular action, and used as the lancet of the surgeon fish (*Acanthurus*) is; but the bilateral symmetry of *Edestus* proves that if employed in this manner it must have been located on the upper margin of the tail or back." The arrangement is considered to be best explained—perhaps precisely paralleled—by *Trygon*, in which "a considerable number, sometimes five or six, defensive spines are set in the place of the posterior dorsal fin. They come into use in succession, like the fangs of venomous serpents. As the anterior one loses its denticles or becomes worn or broken, it falls, and is succeeded by another *from behind.* Yet several may be in existence and effective at the same time, all arising from a common segmented bony base which grows by additions to its posterior extremity." The new spine of *Edestus giganteus* is at least 18 inches in length, by 7½ inches in breadth, and indicates the enormous dimensions to which the fish must have attained, if this ingenious explanation proves true. A. S. W.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—June 6, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. The following letter from H.M. Secretary of State for India accompanying some specimens of rubies in the matrix from Burmah:—

"India Office, Whitehall, S.W., 2nd June, 1888.—Sir,—I am directed by the Secretary of State for India in Council to present to

the Geological Society some specimens of Burmese rubies attached to their matrix, which were procured by Mr. Barrington Brown, at present employed by Government in examining the mines which came into their possession on the annexation of Upper Burmah."—Mr. Barrington Brown writes concerning these specimens thus:—'I send . . six specimens of rubies in granular limestone, where they were formed. They were obtained by blasting, under my direction, in a place formerly mined by natives. . . . As I believe the fact of the ruby being traced to its matrix is new to science, the specimens may prove of interest to scientific men. . . . I should like Professor Judd, President of the Geological Society, to see the specimens.'—I am, Sir, your obedient servant (signed) J. A. Godley.—President, Geological Society."

2. "On the Sudbury Copper Deposits (Canada)." By J. H. Collins, Esq., F.G.S.

These deposits occur in Huronian rocks. The author described two exposures, known as Copper Cliff and Stobie, about 8 miles apart. At the former the ore was found in the face of a cliff of diorite about 40 ft. high.

The ore exists in three distinct forms:—

1. As local impregnations of siliceous and felspathic beds of clastic origin, in the form of patches and strings of cupreous pyrrhotite.

2. As contact-deposits of the same material lying between the impregnated beds and large masses of diorite.

3. As segregated veins of chalcopyrite and of nickeliferous pyrrhotite, filling fissures and shrinkage-cracks in the ore masses of the second class.

The author considered the first as original, or of high antiquity; whilst the two latter are due to segregation produced either by intrusion of diorite, or by internal movements. He compared these deposits with those of Rio Tinto of Devonian age, showing their similarities and differences. At the latter place the intrusive masses are quartz-porphyries, and the metallic deposits consist mainly of bisulphide of iron. The ore-bodies in the Canadian deposits are not so large. From the cupreous pyrrhotite of Sudbury, rich though it be, compared with the Rio Tinto ore, the copper cannot be so cheaply extracted by the wet method, and the ore is of no avail as a source of sulphur. Nickel is everywhere present in the cupreous pyrrhotite of Sudbury, and of no advantage to the smelter. The differences above recorded are probably not due to differences in the containing rocks, since similar differences may be noticed in the pyritous deposits of Canada, where the country rocks are identical.

3. "Notes on some of the Auriferous Tracts of Mysore Province, Southern India." By George Attwood, Esq., F.G.S., F.C.S., etc.

The author was employed during parts of 1886-7 in inspecting a large area of mineral lands in Southern India supposed to be auriferous, and the paper contained the results of his observations.

1. *Melkote Section.*—This section (in the Hassan district of the province of Mysore), starting one mile west of Melkote in a north-easterly direction, exposed gneiss, mica-schist, hornblende-schist,

quartzite, talc- and chlorite-schists, eclogite, and quartz veins, striking generally N. 20° E., and having varying dips. The eclogite was described at length, and special attention was called to the flattening of the contained garnets, which were probably originally almandite; other evidences of great crushing were also noted.

In this section and on most of the schistose lands of Mysore a dull grey, nodular, and botryoidal calcareous deposit, known as "kunkur," is found in nullahs, on hill-sides, and on the detritus of old gold washings, and it was suggested that the contained lime was derived in great measure from hornblende-schists.

Many quartz outcrops, large at the surface but diminishing in thickness downwards, were met with at the east end of the section; these veins have a strike about N. 15° E. to N. 20° E., coincident with that of the schists.

Extensive gold-washings have been carried on in the ravines and hill-sides, and the mode of occurrence and character of the gold were described.

The author considered the schists, as well as the quartz veins, to belong to very old series of rocks, probably Archæan.

2. *Seringapatam Section.*—The second section was taken in a south-easterly direction from the 72nd milestone on the Seringapatam and Bangalore road to the N.W. side of the village of Arakere. Gneiss, hornblende, and mica-schists, etc., were here met with, striking about N. 20° E. with varying dips. These were traversed by auriferous quartz-veins which had been largely worked, and the author gave a description of the former methods of extracting the gold.

At the S.E. end of the section the schists were found to be much broken by porphyrite dykes of much more recent origin, most likely of Tertiary age. A small granite dyke intersected the Elliot Lode diagonally, and was considered to be of Upper Tertiary age.

3. *General Observations.*—The author described the results of traverses of other districts; he pointed out the evidences of great pressure which had broken up the gneissic rocks and compressed the schists, and conjectured that this might have been produced by the gradual rise of the Eastern and Western Ghats, and finally called attention to the great denudation which the Mysore plateau had undergone.

An Appendix by Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S., gave an account of the microscopic characters of the schists, the flattened garnets, the porphyrites, etc., and in this it was pointed out that one set of rocks belonged to an ancient series which, even if wholly or in part of igneous origin, assumed their present mineral structure and condition at an epoch remote from the present, whilst another set was certainly igneous and of more recent date.

4. "On the Durham Salt-district." By E. Wilson, Esq., F.G.S.

In this paper the author described the new salt-field in the North of England, occupying the low-lying country bordering the estuary of the Tees, and situated partly in Yorkshire and partly in Durham.

The history of the rise and progress of the salt-industry in South

Durham was given, since the first discovery of salt by Messrs. Bolckow, Vaughan & Co. at Middlesboro', in the year 1859.

The stratigraphical position of the saliferous rocks of the Durham salt-district was considered in some detail. The diverse views which have been previously expressed on this head were referred to, and reasons given for concluding that all the beds of rock-salt which have been hitherto proved in this field, and the red rocks with which they are associated, belong to the upper portion of the Trias, viz. to the Upper Keuper series (Waterstones subdivision).

The probable area of this salt-field, the limits of the distribution and varying depths of the chief bed of rock-salt, were indicated, and the extent of its supplies pointed out.

In conclusion, the author called attention to the waste, as well as to certain other disadvantages resulting from the process of winning the salt now in operation.

5. "On the Occurrence of *Calcisphæræ*, Williamson, in the Carboniferous Limestone of Gloucestershire." By E. Wethered, Esq., F.G.S., F.C.S.

The small hollow spheres, with varying forms of peripheral appendages, described by Prof. Williamson as *Calcisphæræ*, were found in the Carboniferous Limestone of Flintshire, and were suggested by him to be possibly Foraminifera or the reproductive capsules of some marine form of vegetation, although he admitted that no forms hitherto discovered afforded any definite support to this hypothesis. Prof. Judd expressed a belief that the objects were Radiolaria; whilst Mr. Shrubsole discovered similar bodies in the Mountain Limestone near Llangollen, and conjectured that the described forms included both Foraminifera and Radiolaria.

The author has discovered the *Calcisphæræ* in great numbers in the Carboniferous Limestone of Gloucestershire. He discussed the identity of certain calcareous rings ·005 in. in diameter, seen in sections of the limestone of Clifton, etc., with siliceous bodies which he had described in a recent paper read before the Society, and gave an account of the calcareous and siliceous forms which were both referable to *Calcisphæræ*. He commented upon the character of the carbonate of lime of the calcareous bodies, which presented a granular structure characteristic of the truly organic portion of the limestone, and not a clear crystalline aspect like that of the infilling or replacing calcite; he concluded therefore that the tests had been originally calcareous, and not siliceous replaced subsequently by carbonate of lime. This was urged as a strong argument against regarding the organisms as Radiolaria, and the author, whilst considering it unwise to come to a decided conclusion, believed it safe to say that they were Protozoa.

6. "Second Note on the Movement of Scree-material." By C. Davison, Esq., M.A. Communicated by Prof. T. G. Bonney, D.Sc., F.R.S., F.G.S.

After briefly recapitulating the substance of his previous paper, the author now communicated the results of experiments continued for a year. He gave a figure in which a continuous line represented,

in millimetres, the movements of the upper stone from week to week, whilst a contiguous dotted line indicated the mean ranges of temperature. The rate of descent does not depend solely on the mean range. He gave the following comparison of rates of descent:—

	Average daily range of temperature.	Total mean descent in millim.	Rate of descent in inches per day.
Summer, 184 days......	14°·4 F	8	·00171
Winter, 182 days	8°·0	5⅛	·00121

Thus the changes are not altogether proportional to the ranges of temperature, being relatively higher in the winter months. In considering the influence of rain, he observed that its effects are to slightly increase the rate of descent by diminishing the coefficient of friction, and by lowering the temperature, both as being itself generally colder than the air on the ground surface, and also owing to evaporation. He likewise observed that the rate of descent was nearly doubled during the latter part of the winter, chiefly owing to the effects of snow.

II.—June 20, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Occurrence of Marine Fossils in the Coal-measures of Fife." By James W. Kirkby, Esq. Communicated by Prof. T. Rupert Jones, F.R.S., F.G.S.

This paper recorded the discovery of fossils of good marine types in the Fifeshire Coal-measures. This coal-field is of limited extent, the Coal-measures dipping under the sea towards the east and south. The prevailing fossils are those characteristic of the Coal-measures in other districts, *Anthracosia*, *Anthracomya*, *Anthracoptera*, *Spirorbis*, many fishes, and some few Amphibian remains. Lately a sinking was commenced in the Upper Red beds, below which, and just above a thin band of poor coal, a thick bed of dark shale was passed through, which proved to be tolerably fossiliferous. *Lingula*, *Murchisonia*, and two species of *Bellerophon* occurred. This horizon was subsequently proved elsewhere in the district, and furnished the following fossils from three localities, namely:—*Strephodus sauroides*? Ag. (teeth and scales); *Rhizodopsis*, sp. (scales); Palæoniscid scales; *Diplodus gibbosus*, Ag.; *Mesodomodus*, sp. n.; *Petalodus Hastingsiæ; Discites rotifer*? Salt.; *Discites*, sp. (with longitudinal ribs); *Discites*, sp. (smooth); *Orthoceras attenuatum*? Flem.; *Bellerophon Urii*, Flem.; *Murchisonia* (*Aclisma*) *striatula*, De Kon.; *Sanguinolites*, sp.; *Productus semireticulatus*, var. *Martini*, Sow.; *Discina nitida*, Phill.; *Lingula mytiloides*, Sow.; *Lingula squamiformis;* Crinoid stems (*Actinocrinus*?); Plant-remains (obscure).

Reference was then made to the occurrence of similar fossils in the same formation elsewhere, and particularly in the West of Scotland, North of England, and Lancashire. The author concluded, from the frequency of the beds containing true marine remains, that the Coal-measures were formed in low-lying areas; and that, when the land was slightly depressed, at times the waters of the sea had

access to such spots, bringing back species of shells and Crinoids that had existed in the Carboniferous-Limestone ocean of an earlier period. Some further remarks were made on the peculiar nature of the ordinary fauna of the Coal-measures; and the author observed, in conclusion, that no marine deposits have been observed as yet in the Upper Red beds (d^{51}) of the Fife or other Scotch Coal-measures.

2. "Directions of Ice-flow in the North of Ireland, as determined by the Observations of the Geological Survey." By J. R. Kilroe, Esq. Communicated by Prof. E. Hull, F.R.S., F.G.S.

While the striæ S.E. of a line drawn from Strangford Lough to Galway Bay all trend in one direction, two sets of striæ occur N.W. of that line, which are generally at right angles to each other, and are frequently seen upon the same rock-surface. The direction of one of these is N. by W. in Antrim and Londonderry; N.W. over the highlands of Fermanagh; and N.E., N., and N. by W. in Donegal, etc. That of the second set is W. 25° S., swinging round to W. in Donegal and S.W. towards Galway Bay, and is strikingly persistent throughout. A few striations occur which do not conform to these directions, and are attributable to local ice-flows.

The second set of striations was referred to the ice of the *Scottish Glacial System*, and evidence was cited from the researches of Messrs. Symes and M'Henry, Dr. Geikie, and others in support of this view, which is confirmed by the relative positions of the boulders and their parent rocks. Striæ bearing westward have been observed at a height of 1100 feet in county Mayo.

The effects of the *Irish Glacial System* have been considered by the Rev. M. Close, Mr. G. H. Kinahan, and Prof. Hull. Striations occur up to 1340 feet in Donegal. The ice of this system flowed in a general S.E. direction to the S. of the axis.

With regard to the relative age of the two sets of striæ, it is observable that those bearing northward are by far the most numerous; so that, although it is reasonable to suppose that a considerable accumulation of snow and ice obtained in the Irish area whilst the Scotch system was gathering its maximum strength, the striations produced by this gathering would be largely effaced by the westward-flowing Scotch ice; and that, after the decline of the latter, an independent Irish *Mer de glace* flowed northward and southward, finding its axis of movement in the great central snow-field.

3. "Evidence of Ice-Action in Carboniferous Times." By John Spencer, Esq., F.G.S.

The author combated the notion that there is any *à priori* improbability in the action of ice during the period in question. In the case under consideration, of the two agents, land-ice or floating-ice, he was inclined to adopt the latter, as having been the cause of the phenomena he described. The bed affected is the Haslingden Flag-rock, a member of the Millstone-Grit series, which is directly covered by a shale of the same series. The surface of this Flag-rock is largely striated, the striæ having a N.E. and S.W. direction, and being nearly parallel. The area exposed is 200 square feet. The Flag-rock dips to the east at an angle of 30°; but there seems no possibility

of these striæ having been produced by landslips or local disturbance. A quarry on the same horizon, near Rochdale, exhibits similar phenomena. As collateral evidence of ice-action, he alluded to the boulders frequently found in the coal-seams.

4. "The Greensand Bed at the Base of the Thanet Sand." By Miss Margaret I. Gardiner, Bathurst Student, Newnham College, Cambridge. Communicated by J. J. H. Teall, Esq., M.A., F.G.S.

This bed may be seen between Pegwell Bay on the east and Chislehurst on the west, and a somewhat similar bed occurs at Sudbury, Suffolk. An examination of the Kentish layer showed it to consist of 45 per cent. of quartz, 15 per cent. of glauconite, and 40 per cent. of flint. Amongst the rarer minerals are felspar, magnetite, spinel, zircon, garnet, rutile, tourmaline, actinolite, epidote, and chalcedony; and there are a few microscopic organisms, either Radiolarians or Diatoms, and some Foraminiferal casts.

The Sudbury Greensand has 75 per cent. of its grains consisting of glauconite, and of the quartz- and flint-grains only 10 per cent. are flint; several of the rarer minerals found in Kent occur here also.

The large flint-percentage in the Kentish grains was alluded to in support of the existence of an unconformity at the base of the Tertiary deposits of that area; and the relatively small percentage of flint in the sands now being formed along a very similarly situated shore was suggested to be due to the drifting débris derived from the coasts composed of Tertiary and Wealden rocks, which became mixed with the material brought down by the Thames.

5. "On the Occurrence of *Elephas meridionalis* at Dewlish, Dorset. By the Rev. O. Fisher, M.A., F.G.S.

The author's attention was first drawn to this subject on seeing two molars of an elephant in the Blackmore Museum labelled "Dewlish, Dorset." He at once attributed them to *E. meridionalis*. Subsequently he ascertained that they were part of a find made in 1813 by a Mr. Hall. Dr. Falconer, from rubbings, attributed the teeth to *E. antiquus*; and Dr. Leith-Adams would not allow that they belonged to *E. meridionalis*, because that species had never been found so far west. Last year the author and Mr. Mansel-Pleydell went to Dewlish, and the latter has since continued the workings. The remains have been found high up on the face of a steep chalk scarp facing west, 10 feet below the brow and 90 feet above the existing stream, in such a position as to suggest that the deposit was the result of an undercut of the stream when it flowed at a higher level. It probably lies in the prolongation of a line of fault with a deviation to the east. The following section was given :—

	ft.	in.
1. Chalk rubble	0	10
2. Fine sand and flints, with elephant remains	3	0
3. Sand and ferruginous gravel...		?
4. Flint-material, waterworn		?
5. Sand, the lower portion with different-sized flints ...		?

There were no shells or Microzoa.

The author speculated on the probable lapse of time, and on the importance of the discovery of *E. meridionalis*, a pre-glacial mammal, so far west. A list of the bones found was given.

6. "On Perlitic Felsites, probably of Archæan Age, from the Flanks of the Herefordshire Beacon, and on the Possible Origin of some Epidosites." By Frank Rutley, Esq., F.G.S.

The author has previously described a rock from this locality in which faint indications of a perlitic structure were discernible. In the present paper additional instances were enumerated and a description was given. The perlitic structure is difficult to recognize, owing to subsequent alteration of the rock.

Decomposition-products, apparently chiefly epidote, with possibly a little kaolin, have been found in great part within the minute fissures and perlitic cracks.

The author suggested, from his observations, that felsites, resulting from the devitrification of obsidian, quartz-felsites, aplites, etc., may, by the decomposition of the felspathic constituents, pass, in the first instance, into rocks composed essentially of quartz and kaolin; and that, by subsequent alteration of the kaolin by the action of water charged with bicarbonate of lime and more or less carbonate of iron in solution, these may eventually be converted into epidosites.

He regarded it as probable that the rocks are of later Archæan or Cambrian age.

7. "The Ejected Blocks of Monte Somma," Part 1, Stratified Limestones." By H. J. Johnston-Lavis, M.D., F.G.S.

Introductory.—The author referred to the Hamilton collection, now in the British Museum, and to the work of Prof. Scacchi, who enumerated 52 mineral species as having been found in the ejected blocks, and indicated the importance of these from a geological and volcanological point of view. His own collection contains over 600 specimens, showing the graduation from unaltered limestones, through various stages of change into numerous varieties of "true metamorphic rocks," which, in their turn, shade into igneous rocks more and more approaching the several modifications of the normal cooled magma of the volcano. Moreover, such rocks come from depths where they have not been affected by alterations of a secondary nature.

He then gave a classification of the varieties of ejected blocks. The Tertiary rocks are but slightly metamorphosed, whilst the limestones of Cretaceous or earlier age afford an almost unlimited series of mineral aggregates. Physical changes have converted them into carbonaceous and saccharoidal marbles; next oxides and aluminates have separated, and silicates have been introduced. Such rocks come under the definition of *accidental* ejectamenta. They are only ejected when the apex of the crater-cavity, formed by an explosive eruption, extends below the platform of the volcano into the underlying rocks. He then traced the history of the eruptions of Somma-Vesuvius through divers phases, showing that it was only at a comparatively late period that limestone-fragments were blown out, though this had taken place long before the Plinian eruption. The stratified limestones have been chosen for the first part of this paper, because their original lithological structure acts as a guide as we proceed from a normal limestone to its extreme modifications.

Part I.—The character of the limestones which underlie the platform of Vesuvius may be studied in the peninsula of Sorrento, where the mass attains a thickness of 4700 feet. They are magnesian in varying proportions. A table was given showing twenty-seven analyses, made principally by Ricciardi, the amount of MgO ranging from 1 to 22 per cent. Silica rarely exceeds 2 or 3 per cent., whereas in the greater number of limestones it is absent. The bituminous matter, though a powerful colouring agent, usually exists in quantities too small for estimation, but sometimes reaches 3 per cent. Such are the materials out of which the extraordinary series of silicate-compounds have been developed, and as these materials of themselves could not form peridotes, micas, pyroxenes, etc., it is clear that the silica, alumina, iron, fluorine, etc., must have been introduced from without, viz. from the neighbouring igneous magma. The author then discussed the question of the probable methods, being inclined to favour the notion of vapour in combination with acid gases.

The bulk of the paper was occupied with a detailed description of the microscopic structure of these stratified limestones and their derivatives. The author remarked that the same metamorphic changes may be traced on a much grander scale amongst the ejected blocks, and hinted at the similarity of these changes to those of contact-phenomena as seen elsewhere, and even of regional metamorphism, the two main factors to be considered being the composition of the rock to be acted upon and that of the magma acting.

The changes which ensue in an impure limestone are, in the first place, the carbonization of the bituminous contents, which are converted into graphite; and a kind of recrystallization, approaching the saccharoidal structure, seems to have taken place, although the stratification, etc., is preserved. A few grains of peridote now begin to make their appearance, chiefly as inclusions within the calcite crystals, and thus by degrees the results already recorded are effected. In the early stages only is the metamorphism selective. The order in which the new minerals seem to develope is the following:—(1) Peridote, Periclase, Humite. (2) Spinel, Mica, Fluorite, Galena, Pyrites, Wollastonite. (3) Garnet, Idocrase, Nepheline, Sodalite, Felspar. Many of these minerals are crowded with microliths, which there is reason to believe consist of pyroxene.

ELEVATION AND SUBSIDENCE.

Sir,—In the suggestion as to the cause of subsidence and elevation put forward by Professor Lloyd Morgan,[1] it is not quite clear whether on his hypothesis he looks upon the conversion of molten rock into the crystalline condition as a case of simple condensation by pressure following ordinary lavas, or whether he assumes that after a certain pressure is applied the molten rock will suddenly assume the crystalline condition and contract, and thereby cause

[1] Geol. Mag. July, 1888, pp. 291–97.

subsidence. For the proper estimation of the efficiency of the cause invoked, it is requisite that this should be clearly set forth. That lateral displacement by weight of accumulated sediment together with actual compression of the rocks below may take place in certain cases is extremely probable.

The assumption of the existence of a zone of molten rock at a certain distance below the surface of the earth in so sensitive a condition as to respond to the weight of accumulation by becoming solid or that of denudation by becoming liquid is rather a large one, especially when the physical part is unsupported by experiment or quantitative determination. If these were supplied, it would be a fit subject for investigation, but the suggestion fails as a general explanation of subsidence and elevation, even if the assumptions are admitted, inasmuch as it does not account for the elevation of areas of former great sedimentation, which is one of the most striking facts of geology. T. Mellard Reade.

THE NOMENCLATURE OF AMMONITES.

Sir,—I had not much hope of converting Mr. Buckman from what, in common with Mr. Haddow, I conceive to be the error of his ways; but I wished to protest against the system of which he is an exponent.

He still assumes that *Ægoceras* and *Arietites* are *genera*, which is exactly what I ventured to question. He says I do not attempt to discuss *Lioceras*, but I should have thought he would understand that it could be treated in the same way as *Harpoceras* (if it is a group of equal value). Let us write in catalogues *Ammonites* (*Lioceras*) *elegans*; specialists will doubtless prefer to call it *Lioceras elegans*; but most geologists will probably be content with *Ammonites elegans*, regarding *Lioceras* merely as a subgeneric name.

My chief point, which Mr. Buckman entirely fails to notice, is this, that if the specialists rank *Harpoceras*, *Lioceras*, etc., as genera, each of them may be accredited with a species having the same specific name. Fancy half a dozen different *Amm. elegans* referable to an equal number of these so-called genera.

A. J. Jukes-Browne.

"GEOLOGY FOR ALL."

Sir,—While thanking you for your notice of "Geology for All," perhaps you will permit me to say that what is called a "slip" is explained by the context, and is in accord with the spirit and intention of the book, while the high per-centage of silica in orthoclase is duly acknowledged on page 58, where the fact is wanted.

I may add that my aim was to find a new and intermediate path between the two old and well-beaten ones of Academic or Text-book geology and so-called "popular" or entertaining geology, neither of which in my humble opinion is likely to lead to the end I have in view, namely, a general knowledge of geology by all well-educated people. In the days of Buckland and Hugh Miller, fossils were

marvels, and these certainly attracted much attention to geology. Now they are no longer so, and from my experience, and it is not a small one, they and their nomenclature do much to restrict a knowledge of the great teachings of geology to the limited circle to which your reviewer so justly refers. J. LOGAN LOBLEY.

CITY OF LONDON COLLEGE,
July 16*th*, 1888.

GEOLOGICAL SURVEY OF ENGLAND AND WALES.

WE are informed that Mr. H. W. Bristow, F.R.S., has retired from the Directorship of the Geological Survey of England and Wales, after a lengthened service of forty-six years. Joining the staff of the Survey in 1842, under De la Beche, he commenced field-work in the Silurian regions of Radnorshire, and subsequently surveyed large areas of the Secondary and Tertiary strata, more especially in Somerset, Dorset, Hampshire, the Isle of Wight, and Sussex. This work has formed the basis for all later and more minute observations on the strata. The history of the Survey with which Mr. Bristow has been so long associated has been told in part in the Memoirs of Edward Forbes and Murchison by the present Director-General, and also in the Letters of Jukes; and it is pleasant to read of the early labours of the small yet enthusiastic band of geologists, who numbered only 10 in 1844; but these included Ramsay, Warington Smyth, John Phillips, Aveline, W. H. Baily, and Edward Forbes. In the genial company of Forbes, Mr. Bristow carried on much of his detailed work in the Isles of Wight and Purbeck; and we understand that a new edition of Mr. Bristow's Memoir on the Isle of Wight will shortly be published. Until 1872, when he was appointed Director, Mr. Bristow was more or less actively employed in the field, devoting especial attention in these later years to the Rhætic or Penarth Beds—the latter name being given by him on account of the prominent exposures of these strata on the Glamorganshire coast.

We learn that Mr. H. H. Howell, F.G.S., Director of the Geological Survey of Scotland, now undertakes the additional duties of Director for England and Wales, and his excellent geological work in the Midland counties, the North of England, and the South of Scotland, together with his well-known administrative capacity, will cause the appointment to be hailed with satisfaction.

We have also much pleasure in announcing that Mr. J. J. H. Teall, M.A., F.G.S., has recently joined the staff, and is specially charged with the study of the crystalline schists and the problems of regional metamorphism.

A. B. Woodward, del. et lith. West, Newman & Co. imp.

Æger Brodiei. *H. Woodw.*

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ORIGINAL ARTICLES.

I.—On a New Species of *Æger* from the Lower Lias, of Wilmcote, Warwickshire.

By Henry Woodward, LL.D., F.R.S., V.P.G.S.,
of the British Museum (Natural History).

(PLATE XI.)

THE genus *Æger* of Münster was established in 1839, to contain some of the most beautiful forms of Prawn-like Crustacea found in the Solenhofen Limestone of Bavaria (see Beiträge, vol. ii. p. 64). Dr. Oppel, in his Palæontologische Mittheilungen (Stuttgart, 1862), p. 109, thus defines the genus :

The inner antennæ (antennules), with their long bifid filaments, start from three strong basal articulations, and attain in most specimens to twice the length of the whole body. The antennal scales are thin and very long. The basal joints of the inner antennæ are finely serrated along their border. They are much elongated, and project further in front of the head than the outer antennæ, as is the case in the existing Shrimps.

The rostrum of the cephalothorax forms a long and slender spine with several small tubercles along the sides. It may even attain the length of the cephalothorax. These characteristics may not however all be constant in the genus *Æger*.

The outer maxillipeds or jaw-feet are of great length, and are furnished on either side with a row of slender moveable spines of considerable length. A very small spine usually springs from the base of each of the larger spines. The first three pairs of true thoracic feet are chelate at their extremities, and are also partially covered with similar moveable spines.

The first pair of chelipeds are the smallest, the second are somewhat larger, whilst the third pair are always the largest.

The fourth and fifth pairs of legs are monodactylous, and are generally very long and slender, but vary in different species.

The surface of the whole of the integument is thin, but very finely granulated, even the caudal plates displaying this character.

The form of the abdomen furnishes no marked peculiarities. The false abdominal feet with their basal articulations are frequently preserved. The outer caudal lamellæ are divided diagonally by a line of articulation near their distal extremity.

Through the kindness of the Rev. P. B. Brodie, M.A., F.G.S.,

Rural Dean, and Vicar of Rowington, near Warwick, I have received a block of Lower Lias Limestone from the "Insect-bed" (*Ammonites planorbis*-zone) at Wilmcote, containing a very well-preserved specimen of a Macrourous-Decapod Crustacean referable to the genus *Æger* of Münster.

The specimen was obtained by the Rev. H. E. Lowe, M.A., residing at Wilmcote, who procured it from one of the quarrymen, and afterwards generously presented it to Mr. Brodie.

Like similar fine-grained fissile limestones, such, for instance, as the Lithographic Stone of Solenhofen in Bavaria, these Lias beds divide up into more or less numerous layers, the fossil-remains being exposed as impressions and counterparts, upon the corresponding surfaces of the slabs when split along their laminæ. In this instance, however, only the single slab containing one side of the organism, has been preserved, so that some parts of the surface of the body-segments and appendages, which had adhered to the counterpart, have been lost with it.

The specimen, which is of the bigness of an ordinary-sized prawn —the body being 4½ inches in length—is lying upon its left size.

Its rostrum, which is not serrated, is exceedingly slender, and as long as the entire carapace. The right ophthalmite, and its peduncle, are very well preserved. Only traces of the first or inner pair of antennæ can be detected; but the outer antennæ, with their long multiarticulate filaments, can readily be observed, together with the prominent spine near the base of the same that gives support to the long oval antennal scale, the impression of which can also be clearly made out. Next is seen a pair of extremely long spinigerous maxillipeds, with simple non-chelate extremities, their four distal joints armed with two rows of long, sharp, and slender articulated spines arranged at regular distances apart along each border.

Next follows the first pair of walking-legs, which are slender and shorter than the maxillipeds, and are provided with chelate terminations. The second pair of legs are also chelate, and similar to the first. The third pair are broken off near the body. The fourth and fifth pairs of limbs are long and very slender, and have likewise simple monodactylous terminations.

The carapace is twice as long as it is deep, its surface smooth, and, where preserved, of a rich brown colour. Just over the branchial region the carapace (*branchiostegite*) is wanting and we see exposed the vertical ridges of the calcified endophragmal system, consisting of the infoldings of the lateral walls of the thorax, to which the legs are articulated, and which give attachment to the muscles of the limbs, and upon the outer face of which, but covered by the over-arching branchiostegite, the branchiæ or gills were situated.

The specimen measures 106 millimètres in length by 40 mm. in depth, and displays the cephalothorax 53 mm. long by 20 mm. in depth, the rostrum being 24 mm. long, the pedunculated ophthalmite 4 mm. long.

Behind the cephalothorax are seen the six abdominal segments of nearly uniform size, the last supporting the 'telson' or terminal

joint, which is slender and pointed, and has the caudal lamellæ of the 6th segment lying close beside it; the outer one of which is marked by a transverse articulation near its lower extremity. The false abdominal feet, with their basal joints and their bifid multiarticulate appendages (exopodite and endopodite), are also clearly seen.

In 1866 I described a new species of *Æger* from the Lias of Lyme Regis, Dorset (see GEOL. MAG. 1866, p. 10, Pl. I.). This specimen, which I named *Æger Marderi*, is much larger, and altogether more robust, with shorter and stouter limbs than that now under consideration. Mr. Brodie's specimen is not only smaller, but the limbs are much longer and more delicately slender.[1]

Having many beautiful examples of these elegant Crustaceans from Solenhofen now before me (part of the grand collection formed by Dr. Haberlein, and purchased of him in 1863 for the British Museum), I have been able to study and compare this fossil from Wilmcote with these, and also with that from Lyme Regis referred to above, and I am of opinion that it is specifically distinct from all these, although the species have, as a whole, a well-marked generic facies. I propose, therefore, to name this form *Æger Brodiei*, in honour of my valued geological friend, the Rev. P. B. Brodie, whose labours in the Liassic beds of Warwickshire and elsewhere, extending over half a century, have resulted in a large accession of interesting and beautiful Arthropoda to the Liassic Fauna of Britain.

II.—THE JORDAN-ARABAH DEPRESSION AND THE DEAD SEA.

By ISRAEL C. RUSSELL,

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(*Concluded from the August Number*, p. 344.)

Lacustrine History of the Dead Sea Basin.

THE occurrence of numerous terraces on the mountain slopes overlooking the Dead Sea has been reported by several observers, but no accurate measurements of their elevations or definite correlation of the terraces on the opposite slopes of the depression, seem to have been attempted. In the central part of the Wady Arabah on the west flank of the promontory known as Samrat el Fedan, a terrace, or perhaps more properly a gravel bar, has been observed by Hull[2] at an elevation of about 1300 feet above the Dead Sea. This is apparently a definite record of the surface level of the Dead Sea during a former period. On the sides of the Jordan valley the terraces range in height from a few feet to 750 feet above the river. The measurements reported show great variation due principally to an inclination of the surfaces of the terraces, towards the centre of the valley, but indicating also that they are not horizontal in the direction of drainage. The terraces of the Jordan valley, although

[1] In describing the Lyme Regis fossil, I erroneously spoke of the long spinigerous maxillipeds as the first pair of thoracic legs.

[2] Geol. and Geog. of Arabia Petræa, Palestine, etc., page 87.

usually referred to as lake terraces, seem to admit of another interpretation.

The Dead Sea basin has been deeply filled, especially in its northern and southern portions, by lacustrine sediments, supplemented by gravel and sand washed from tributary valleys and neighbouring alluvial slopes. It seems probable that these deposits filled the basin from side to side in the Jordan valley and in the Wady Arabah, but not so completely as to form a level floor throughout. When the waters of the ancient lake fell to a lower level than the surface of the sediments in question, the Jordan flowing from the north and the Jeib from the south, toward the Dead Sea, cut channels in the previously formed deposits. Pauses in the lowering of the lake surface would establish a base level of erosion for the inflowing streams, thus allowing them to widen their channels, so that when another lowering of the lake occurred and the streams re-commenced the excavation of their channels, a terrace would be left on the sides of their valleys. These terraces would slope with the grade of the streams which formed them, and on reaching the Dead Sea basin, would unite with the horizontal terraces formed by the waters of the inclosed sea.

This interpretation of the history of the terraces of the Jordan valley is strengthened by the following observation recorded by Hull in the narrative of his journey of exploration.[1] "All these terraces (along the Jordan near Jericho), excepting perhaps the upper, have doubly sloping surfaces, both toward the centre of the valley and toward the Salt Sea. The upper terrace only slopes toward the centre of the valley, as its upper surface corresponds almost exactly with the terrace of Jebel Usdum, and the other old sea margins, near the southern end of The Ghôr."

Sections of the material filling the Wady Arabah near the steep descent to the plain of the Dead Sea show fine lacustrine sediment at the base, passing into sand and gravel in the upper portion. The surface of this deposit rises when followed southward or up the valley, but breaks off abruptly, as mentioned above, in a steep escarpment about six hundred feet high at the north, facing the depression now holding the Dead Sea. The structure of this deposit so far as known, as well as its topographic form, suggests the probability that it is of the nature of a delta, the steep lakeward scarp of which has been cut away by the waves and currents washing its base. A similar interpretation will apparently apply in many ways to the facts reported concerning the material filling the Jordan valley. A detailed study of these deposits is required, however, before the mode of their formation can be definitely determined.

Lake beds are mentioned by Hull, and others, as existing not only in those portions of the basin adjacent to the Dead Sea, but at high altitudes near both the northern and southern portions of its basin. In Wady Arabah fine, evenly stratified lacustrine sediments charged with freshwater shells, were observed at an elevation of 1400 feet above the present surface of the Dead Sea.[2] In the same

[1] "Mount Seir, Sinai and Western Palestine," p. 162.
[2] Geol. and Geog. of Arabia Petræa, Palestine, etc., p. 80.

basin, near the Sea of Galilee, about 175 miles to the north of the locality mentioned above, other lake beds have been observed at about the same level. These observations, and others of a similar nature which might be cited, show very clearly that the Dead Sea basin was once occupied by a freshwater lake, whose bottom at certain localities was 1400 feet higher than the present surface of the Dead Sea, or at about the level of the Mediterranean.

The surface of this lake during its greatest expansion must necessarily have been at a higher elevation than the deposits accumulated on its bottom, but unless the beach observed by Hull in the Wady Arabah, of which mention has already been made, indicates the level of the ancient lake during the time the lacustrine sediments were deposited, we have no observations of shore records that can be correlated with the formation of the higher sedimentary deposits. Providing no change has taken place in the depth of the Jordan-Arabah depression since this great freshwater lake deposited its high-level marls, it must at one time have been about 2700 feet deep. Its length from north to south probably exceeded 200 miles, its average width being from eight to nine miles. Its full extent cannot be definitely known, however, until its shore records have been studied and their extent accurately mapped. Its depth is also uncertain, and has possibly been considerably overestimated, as will appear on the following page.

The existence of calcareous tufa on the terraces of the Jordan and in the lower portions of the lateral gorges opening into The Ghôr, as observed by Johnson and Lartet, show that calcium carbonate was among the first precipitates thrown down by the waters of the ancient lake. The presence of freshwater shells in these tufas is to be expected, as such deposits may be formed from the waters of lakes that are essentially fresh. Future observers should also look for alternations of various varieties of tufa, for the reason that varying deposits of this character record changes in the chemistry or perhaps variations in the temperature, of the water from which they are precipitated.

Near the southern border of the Dead Sea, at a locality called Jebel Usdum, or Salt Mountain, there is a well-marked terrace, the surface of which has an elevation of about 600 feet above the Dead Sea, and corresponds with the level of the escarpment previously mentioned farther to the south. It is also represented on the east side of the valley, as well as near the mouth of the Jordan. The detached portions of this terrace, which is the most pronounced of any in the basin, mark the boundaries of the profound gorge known as The Ghôr. The escarpment at Jebel Usdum exposes the edges of horizontal strata and owes its precipitous character to the removal of the eastern portion of the deposit. In this respect it corresponds with the escarpment at the south end of The Ghôr. The lower portion of the cliff at Jebel Usdum consists of a layer of rock salt from 30 to 50 feet thick, resting on beds of gravel, shales and laminated sandstone.[1] Above the stratum of salt are some 400 feet of evenly-bedded

[1] Mount Seir, Sinai, and Western Palestine, p. 131.

calcareous marls, with gypsum. H. C. Hart, the only observer who has ascended Jebel Usdum, reports that the salt appears to cease at about 100 or 150 feet, and that the remainder of the elevation is composed of white powdery marl.[1] These observations apparently leave no doubt that this deposit, as concluded by Hull, was formed during a previous stage in the history of the Dead Sea, and that it is synchronous with the lacustrine beds exposed in the escarpment south of the Dead Sea, in the Lisan (the peninsula at the south-east border of the Dead Sea) and in the Jordan valley.

It is evident, therefore, that the stratum in question records a period of long duration, during which the water of the lake was a saturated brine, from which sodium sulphate and sodium chloride were precipitated. The marls and clays resting on the saliferous strata show that the lake subsequently became less salt, and at the same time rose to a higher level. It follows from this that the strata of salt and gypsum must have been deposited during a period of concentration intervening between two high water stages. In order to prove or disprove this inference, search should be made in other portions of the basin for lacustrine beds belonging to two high water stages, separated by beds of gravel and other debris indicative of a period of low water. An unconformity between the upper and lower lake beds due to the erosion of the lower member during an intervening period of desiccation should also be looked for. The record of a period of low water is perhaps indicated in a section of lacustrine deposits exposed on the east side of the Dead Sea, which has been described and figured by Lartet,[2] but this observation is not sufficiently definite to enable one who has not visited the locality to make a full interpretation of its meaning.

As the Dead Sea now has a maximum depth of 1278 feet, and the surface of the terrace at Jebel Usdum is 600 feet above its surface, it follows, providing there has been no orographic change, that the ancient lake after the deposition of the salt bed must have been more than 1900 feet deep and greatly expanded beyond its present limits. The concentration of so great a body of highly saline water to less than two-thirds its original volume, as would have been the case had its contraction to the present limits of the Dead Sea been the result of increased evaporation simply, would have produced such a vast precipitation of sodium chloride and other salts that one would expect to find abundant records of the occurrence, had it taken place. The absence of such deposits is negative evidence which apparently indicated that the entire sea was never sufficiently saturated to precipitate saline matter, or else that an important change has been made in the depth of its basin since the salt bed at Jebel Usdum was deposited.

Two other hypotheses present themselves in this connection, each of which seems worthy of attention.

[1] The strata composing the cliffs at Jebel Usdum, however, are considered by Lartet as being of even older date than the origin of the Dead Sea basin.

[2] Expedition géologique de la Mer Morte, Paris, 1877, pp. 175–176, pl. 3, fig. 3; also in Essai sur la géologie de la Palestine, Paris, 1869, p. 240.

The first hypothesis is that the strait separating the Lisan peninsula from the west shore of the Dead Sea was formerly contracted so as to partially shut off the southern end of the lake from the main water body, and that evaporation in the restricted basin thus formed was greater than the amount of water contributed to it by streams and springs. The result of these conditions would be an influx of water from the main or northern water body and a deposition of salt in the partially inclosed southern basin. If this process continued for a considerable time, a heavy deposit of salt would result, which might become buried beneath lacustrine marls when an increase in humidity caused the two basins to unite. In this manner the great deposit of salt along the south-west border of the Dead Sea with its covering of marl, as well as the absence of similar saline deposits in other portions of the basin, can, apparently, be accounted for.

The sequence of events here postulated is suggested by the topography of the shores of the Dead Sea. As indicated on the maps accompanying the reports of the U. S. Expedition, the strait referred to in the above paragraph is two miles wide and from twelve to eighteen feet deep. The area south of this contraction, and now partially shut off from the main body of the Dead Sea, has a surface sixty square miles in extent. If this basin should be filled to the horizon of the highest salt deposits at Jebel Usdum, its area would probably exceed a hundred square miles. A contraction or filling of the strait connecting the two divisions of the sea, as suggested above, possibly by the construction of embankments across it, would initiate conditions similar to those now to be observed on the east shore of the Caspian, where a gulf known as the Kara Bugaz furnishes an evaporating basin for the waters of the main sea. In this instance the amount of water reaching the Kara Bugaz annually through streams and springs, etc., is much less than the mean annual evaporation from its surface, consequently a current flows continually from the Caspian into the gulf. Owing to these peculiar conditions a precipitation of salt is taking place from the highly concentrated waters of the gulf, while the main water-body contains only a small fraction of one per cent. of saline matter in solution. Should the Caspian rise a few hundred feet, the Kara Bugaz would have free communication with the main sea, and the beds of salt in its bottom would become covered with lacustrine sediments, probably charged with freshwater shells. The record thus produced would be essentially the same as the section now exposed on the south-west border of the Dead Sea.

The second hypothesis is that the Dead Sea basin throughout was far more shallow than at present at the time of the deposition of the rock salt and gypsum on its south-west border, and that subsequently it rose sufficiently to bury these deposits beneath lacustrine sediments. After this rise a movement took place along the Jordan-Arabah fault and deepened the basin; or, it may be suggested, that the change was due to the subsidence of an orographic block situate beneath the Dead Sea, and included between the main fault and a secondary fracture branching from it. At a later date the

waters of the lake were again concentrated, and the present condition of the basin resulted. These changes must have been accompanied by many minor oscillations of humidity, and consequently by many changes of lake level; which were accompanied in turn by many variations in the character of the precipitates thrown down from the lake waters.

A deepening of the central depression in the manner postulated would not only lower the lake surface without forming saline deposits, but would enable its waves to erode the surrounding shores and form cliffs in the previously formed sedimentary beds, like those at Jebel Usdum and ed Debbeh. The lowering of the Dead Sea would also allow the inflowing streams to cut terraced channels through the previously formed lacustrine sediments, its effect being in this respect essentially the same as the lowering of the lake surface by evaporation.

The effect of a movement along the Dead Sea fault of the nature we have suggested, on the history and condition of the Sea itself, renders the study of this displacement of unusual interest. In this connection it is desirable not only to have observations on fault scarps in lacustrine marls and clays and in alluvial deposits if such exist, but we desire also accurate measurement of the elevation of the principal terraces and beaches on the borders of the Dead Sea and in the Jordan valley. Three lines of level run from the Dead Sea surface up the borders of its basin on both the east and the west, to beyond the highest of the ancient lake records, and so located as to cross the best-defined terraces, besides two or three cross-sections of the Jordan valley showing the elevation of the terraces there existing, would give sufficient data both in reference to east and west and north and south axes, for determining if recent orographic movement has taken place in the Dead Sea basin or not. The lines of level suggested could be connected with the soundings of the Dead Sea, and thus give accurate profiles of the basin.

Certain writers have considered that the Jordan-Arabah depression was formed in Tertiary times beneath the ocean, and that when the land rose, the basin was occupied by ocean water. So far as we are aware, no evidence of sediments containing marine fossils has been found in the basin. It has been argued in this connection, also, that the fauna of the Sea of Galilee must have been derived from the ocean, being entrapped in the valley at the time of the emergence of the land.

That the fauna of the Dead Sea basin is specialized, and differs from the faunas of neighbouring drainage areas, is not a fact peculiar in itself. On the contrary, an insular fauna is to be looked for in any basin that has been cut off from oceanic drainage for a long period.

It seems to the writer that there are sufficient facts to indicate that the Jordan drainage was once connected with other river systems, but has been isolated sufficiently long for its fauna to undergo an independent development, and thus become differentiated from the life of neighbouring rivers. Space however will not admit

of our presenting more than a suggestion of the arguments which might be advanced in this connection.

From a study of the fishes of the Jordan drainage system, Günther[1] concluded that "The system of the Jordan presents so many African types that it has to be included in a description of the African region as well as the Europeo-Asiatic." A similar conclusion has been advanced by Tristram in his great work on the Fauna and Flora of Palestine.[2] This evidence, so far as it goes, is certainly on the side of a former connection of the Jordan with other drainage systems.

Besides the facts furnished by the fauna of the Jordan drainage system in reference to a former connection with other drainage areas, we have physical evidence bearing on the same question.

The Jordan-Arabah depression receives tributaries from the east and west through deeply eroded stream channels, which were cut to their present depth before the occupation of the basin by the lake which deposited sediment over so large a portion of its area. The fact that these tributary channels were cut before the existence of the lake, the sediments of which partly fill them, is in itself sufficient proof that the basin at one time had free drainage. The present topography of the basin indicates that the ancient drainage was southward through the Gulf of Akabah, but other outlets to the sea may have existed at various times during the earlier portions of its history. One of these, it may be suggested, may have been situated at the Pass of Jezreel, at present the lowest point in the rim of the basin. It is possible also that a former outlet has been concealed beneath the recent overflows of basaltic lava near the Sea of Galilee. These are mere suggestions, however, and we know of no facts, either to prove or disprove them.

The change from the conditions of free drainage to those now prevailing seems to imply orographic movements, which cut off the Dead Sea basin from communication with the ocean and admitted of the existence of an inclosed lake.

Instead of the evaporation of a single lake in this basin, as has been assumed by certain authors, we should expect in scanning its records to find evidences of many fluctuations of water-level, and, consequently, marked changes in its fauna and flora, as well as great variation in the chemical composition of its waters. We should look especially for the records of two periods of humidity, separated by a time of extreme aridity, during which the lake waters were concentrated and deposited salt and gypsum. Following the last high-water stage, we should as a working hypothesis, postulate orographic movements which increased the depth of the basin several hundred feet, thus lowering the surface of the lake; accompanying or succeeding this movement was a climatic oscillation which caused the lake to contract owing to a decrease in humidity and an increase in precipitation.

[1] Quoted by W. H. Hudleston on the Geology of Palestine, Proc. Geologists' Assoc. vol. viii. p. 47.

[2] London, 1864, p. xii.

It has been concluded by those most familiar with the Dead Sea basin, that the ancient lakes which occupied it did not overflow. This conclusion is based on the fact that the highest terrace observed and the highest exposures of lacustrine sediments that have been noted, are several hundred feet lower than the bottom of the pass leading to the Gulf of Akabah, which seems the most probable location of an ancient outlet if one existed. It is to be remembered in this connection, however, that a special examination of the terraces in question has not been made, and from the reports published it is not evident that the highest water-record reported is the highest that exists. A critical examination of the pass mentioned above, in reference to the possible existence of a stream-cut channel across it, does not seem to have been made. If evidence of such a channel should be found, the occurrence of a wave-cut terrace at the same horizon on the borders of the basin to the north would be expected.

Among the many observations desired of the explorer in Palestine and adjacent regions, we would suggest in addition to those already mentioned, a measurement of the rate of evaporation from the surface of the Dead Sea, and the rate of evaporation of fresh water under the same general conditions. Also, a study of the succession and character of the precipitates which would be obtained on evaporating the water of the Dead Sea. The influence on the character of the salts thus obtained, of changes of temperature similar to the annual variations which occur in Palestine, should likewise be considered.

Similarity of the Dead Sea basin to the Great Basin in America.

There are so many corresponding features between the structure, recent geological history, scenery and present climatic condition of the Dead Sea basin and the Great Basin in our own country, that I am tempted to compare the two in detail. Space will not admit, however, of more than a brief summary of their points of resemblance.

The Jordan-Arabah depression is an isolated example of a type of fault basin which has been repeated many times at about the same date, in the western part of the United States, where the "basin range structure" prevails. This structure in America was impressed on a region which previously drained to the ocean, thus presenting a sequence of events which seems to have had a parallel on a smaller scale in the Dead Sea basin. The depressions which resulted from dislocation both in Asia Minor and in the Far West,[1] became the basins of large lakes during the Quaternary period. In the Great Basin some of the ancient lakes overflowed, others were not drained, and as in the case of the Dead Sea, became concentrated brines. The lakes in both instances were fresh during their greatest expansion, but became saline when concentrated. The lakes referred to in America had two high-water stages separated by a period of

[1] This convenient but indefinite term has come down to us from the time when the western part of the United States was but partially explored, and refers to the vast region west of the bold, eastern face of the Rocky Mountains. It is in this region, between the Rocky Mountains and the Sierra Nevada, that the area of interior drainage termed the Great Basin, mentioned several times in this paper, is situated.

low-water or of complete desiccation: and the same seems to be true of the ancient lake of the Dead Sea basin.

Accompanying the two great expansions of the Quaternary lakes of Utah and Nevada, was an increase of perennial snow on the neighbouring mountains and the production of glaciers, some of which were several miles in length, in the higher portions of the Sierra Nevada and Rocky Mountains. It is known from the observations of Sir Joseph Hooker, that glacial moraines occur about the base of Mount Lebanon; and it seems fair to infer that glaciers of considerable magnitude existed on the higher mountains of Asia Minor during the time that the Jordan-Arabah depression held a great freshwater sea.

At present the regions we are comparing are each arid and but thinly clothed with vegetation. Agriculture in each instance is largely dependent upon irrigation. The mountains in each country are remarkable for their brilliant colours, for the ruggedness of their sides, and for their angular outlines; in each case they are surrounded by an atmosphere of great transparency, which renders distances deceptive to those familiar with more humid regions. The desiccated lake basin known as "playas" in the Far West are represented by similar mud plains in Palestine and adjacent regions, which are dry and hard in summer and shallow lakes in winter. The dry water-courses known as arroyas in the West have their counterpart in the wadys of the East. About the bases of the steep escarpments bordering the Jordan-Arabah depression and in other similar localities, there are alluvial cones formed of debris swept out of tributary gorges and deposited as half-cones sometimes several hundred feet high, against the sides of the valleys. Similar alluvial cones of great magnitude occur again and again about the bases of the abrupt mountains of Utah, Nevada, Arizona, and neighbouring regions. The reader who has traversed the desert valleys of the Far West will no doubt be interested to learn that the familiar *Artemisia* thrives also in the Holy Land.

Many other similarities might be pointed out between the lands under comparison, especially with reference to those features which attract the artist's eye. It is to be remarked in this connection, however, that while the Far East has furnished inspiration for hundreds of painters, the Far West, with equal wealth of colour, fully as picturesque inhabitants, and far more magnificent mountain forms, still remains almost an undiscovered country.

III.—Vertebrate Palæontology in some Continental Museums.

By A. Smith Woodward, F.G.S., F.Z.S.;
of the British Museum (Natural History).

HAVING lately had the privilege of visiting several of the Continental Museums containing collections especially of Palæontological importance, some notes will perhaps be acceptable upon the present aspect of that branch of the science in which the writer is particularly interested. Such a broad survey imparts so many new ideas, and leaves so many pleasant memories of

Naturalists in the midst of their work, that it is impossible adequately to incorporate the results in any brief notice; but a few points at least seem to be of general interest.

Brussels.

To students of the Palæontology of the Vertebrata, the fine Royal Museum in Brussels has become so well known, through the researches of Dupont upon cavern-remains, of van Beneden upon Pliocene Cetacea, and of Dollo upon Wealden Reptiles, that its riches scarcely require enumeration. The work upon the huge Iguanodons is at present almost suspended; and the elucidation and arrangement of the Reptiles of the Belgian Lower Tertiaries is now in active progress. The Chelonia, especially, are receiving M. Dollo's attention, and among the latest acquisitions are remains of the large Athecan *Psephophorus rupeliensis*, from the Rupelien beds of the neighbourhood of Antwerp, of which one remarkably complete skeleton is already mounted.

Among fishes, portions of two fine skeletons of *Carcharodon heterodon*, from the Rupelian Beds of Boom, were added last year; and the Collection also comprises the large series of teeth of *Carcharodon* and other Belgian Tertiary Sharks, arranged, and in part studied, by the late Capt. Le Hon. The majority of the fish-remains from the Belgian Cretaceous and Tertiaries are very fragmentary, and a few have already been described by van Beneden and Storms; but when the Museum Collection is carefully studied and arranged, several new forms will doubtless be recognized, and further information afforded concerning some species already known, as in the case of the Selachian *Rhombodus Binkhorsti*, from the Maastricht Chalk, of which a fine small connected series of the teeth is preserved. The collection of Wealden fishes from Bernissart is still undetermined, but will shortly be studied by MM. Dollo and Raymond Storms; and this will yield several species related to, if not identical with, those from the English Purbeck.

The series of Selachian teeth from the Carboniferous Limestone of Belgium, described by the late Prof. L. G. de Koninck, is also preserved here, and will, in part, require revision in the light of more recent discoveries. *Pleurodus* is represented under the name of *Tomodus laciniatus;* and, as already noted by St. John and Worthen, *Streblodus tenerrimus* is founded upon a tooth of *Sandalodus.*

Bonn.

The Museum of the University of Bonn is contained in the palatial rooms of the old Castle of Poppelsdorf, and comprises among its Pleistocene Vertebrata the far-famed Neanderthal skull. The originals of Goldfuss' early memoirs are also here, including the well-known *Pterodactylus crassirostris* from Solenhofen—the basis of the restoration with an erroneously added fourth clawed finger, still surviving in many text-books. Some fragments of Devonian fishes from the Eifel are among the most recent additions; and Dr.

Hans Pohlig is to be met at work here, having just completed a memoir on the Pleistocene Elephants. The small Museum of the Naturhistorischer Verein is also full of interest for the stratigraphical geologist; and the fine geological repositories of Messrs. Krantz & Co., and B. Stürtz, may always be found to afford some novelties.

Berlin.[1]

In Berlin, the University Natural History Collections are at present being removed from the old building to the grand new Museums and Laboratories near the Institute of the Landesanstalt. Through the kindness of Prof. Dr. Dames, however, the writer had the opportunity of examining all the fossil fishes, and a few of the higher vertebrates, including the unique *Archæopteryx* from Solenhofen, rendered classical by the Professor's memoir. Among the earlier fossil fishes is a large series of the Lower Permian nodules from Rhenish Prussia, exhibiting remains of *Pleuracanthus* (*Xenacanthus*), *Acanthodes, Conchopoma,* and various Palæoniscidæ. The examples of *Pleuracanthus* and *Conchopoma* are especially interesting, several being described and figured in Kner's memoirs, and others adding much to our knowledge, at least of the former genus. The systematic position of the problematical "Dipnoan" *Conchopoma* is still very doubtful; the scales may be rhombic, as supposed by Kner, but the characters cannot be definitely determined. The fossil fishes of Solenhofen are also represented by a large collection; and the type of the Wealden *Pholidophorus splendens*, Strückmann, shows that this fish is either referable to *Semionotus*, or to the same genus as "*Lepidotus*" *minor* of the English Purbeck. An interesting series of fossil fishes from Mount Lebanon, collected by Dr. Fritz Noetling, has lately been received, and will afford several novel anatomical facts in regard to the members of this fauna, if not any new species. The Monte Bolca fish, described by Agassiz as *Diodon tenuispinus,* is also here; and a large series of Selachian and other remains from the Tertiary of Birket-el-Qurūn, Egypt, described by Dr. Dames in 1883. The Museum is fortunate in having secured the services of Dr. Ernst Koken, who entered upon his duties last spring, and the Professor, Dr. Dames, has lately extended his field of operations, having elucidated, in connection with the few specimens in Berlin, all the principal fossil Ganoids from the extra-Alpine Muschelkalk preserved in the Museums of Europe.

The Museum of the Prussian Survey and School of Mines is arranged upon the plan of the Jermyn Street Museum of Practical Geology, and does not contain many vertebrate fossils of note. Here, however, is the fine skull of a Stegocephalian from the Lower Rothliegendes of the Bavarian Palatinate described under the name of *Weissia bavarica,* by Dr. Branco, in 1886; also some of the originals of the same Professor's recent Memoir on *Lepidotus,* and a few fragments of German Devonian Fishes.

[1] Between Berlin and Munich the writer was accompanied by Mr. James W. Davis, F.G.S., of Halifax.

University Museum, Leipzig.

In the University of Leipzig, Systematic Palæontology is almost excluded by the overwhelming pursuit of Stratigraphy, Petrology, and Mineralogy; but the collection of Stegocephalia from the Saxon Rothliegendes is entirely unique, and is rendered all the more instructive by the exhaustive descriptions and enlarged figures published in Prof. Dr. Credner's well-known series of memoirs. The specimens are numbered and arranged in cabinets in the order in which they are described, as illustrating to a certain extent the life-history of each species; and accompanying all the groups are copies of the Professor's detailed drawings mounted for convenient reference. Large restored figures have also been made in the form of wall-diagrams; and the only point that appears to the present writer somewhat speculative is the arrangement of the scutes in the pelvic region, of which the evidence is not altogether clear.

Dresden.

The Geological and Palæontological Collections at Dresden, so long presided over by Prof. Dr. Geinitz, are located with the other State treasures in the old Palace of the Zwinger. With his able coadjutor, Dr. J. V. Deichmüller, the Professor still welcomes visitors to the scenes of his extended labours; and the Museum comprises a large number of vertebrate fossils of the greatest interest. Among Permian fishes, a *Pleuracanthus* from Bohemia is noteworthy for the perfection of the pelvic fins; and several teeth and a fin-spine from the Kupferschiefer elucidate some of the characters of the Cestraciont Selachian, *Wodnika*. A Kupferschiefer tooth, named *Hybodus Mackrothi*, is also interesting. A large series of Solenhofen Lithographic Stone fishes forms the basis of Prof. Dr. Vetter's important memoir, published in the "Mittheilungen" of the Museum in 1881; and an example of the rare Solenhofen Ray, *Asterodermus platypterus*, is figured in Bronn's "Lethæa." Several fragmentary fish-remains from the Saxon Chalk are described and figured in Dr. Geinitz' "Elbthalgebirge"; and a collection from the Eocene Helmstedt Phosphate Beds is made known in the Professor's papers upon those deposits. Among other vertebrates, there are also Stegocephalian fossils from the Saxon Rothliegendes, described conjointly by Drs. Geinitz and Deichmüller.

Prague.

The fame of the vertebrate fossils in the Royal Bohemian Museum at Prague has already spread afar, through the labours of the Director, Prof. Dr. Anton Fritsch. The collection is still retained in the ancient building in the Graben, the fine new Museum at the end of Wenzelsplatz being still unfinished, and probably not destined to be opened for public inspection for at least five or six years. The Vertebrate Fauna of the Bohemian Lower Permian is especially well represented, as may be inferred from Dr. Fritsch's great memoir upon the Stegocephalia and Reptilia, now completed, and as will become still more evident from the forthcoming memoirs upon the Dipnoi,

Ganoidei, and Selachii, the first of these three already prepared for issue. The pyritous character of the Gaskohle, from which many of the specimens are obtained, renders it almost impossible to ensure their permanent preservation; hence the importance of the exquisite fac-similes produced by the electro-deposition of copper, now to be seen in nearly all the principal museums, these reproductions being almost as satisfactory and reliable for examination as the originals temporarily surviving in Prague. Among the undescribed Permian fishes, the series of *Pleuracanthus* (*Xenacanthus*) is unrivalled, and Dr. Fritsch has already given naturalists a slight foretaste of the "good things to come" in a recent figure and description of the pectoral fin. One specimen shows the entire fish, in beautiful preservation, confirming in an interesting manner the recent discovery of M. Charles Brongniart in France. Bohemia also yields many Chalk fishes, and the Royal Museum contains a large series, described and undescribed. Nearly all are in a very unsatisfactory state of preservation, compared with those of England, being merely in the form of hollow moulds. They indicate a fauna very similar to that of the English Chalk, and in some cases elucidate types of which very little is known in this country; some large specimens of *Halec Sternbergii*, for example, reveal almost the entire skeleton of this ancient Clupeoid.

Among later vertebrates a large part of the skeleton of a young *Dinotherium* from Bohemia, still undescribed, is noteworthy; and there are numerous bones from the Pleistocene deposits of the country.

At the German University in Prague Prof. Dr. Gustav Laube also presides over a large palæontological collection, comprising a few of the Permian Stegocephalians described by Dr. Fritsch, and the originals of the Cretaceous *Protelops Geinitzii* and *Osmeroides levesiensis*, made known by the Professor himself in 1885.

The mission of the Palæontologist in visiting Prague is also incomplete without a brief pilgrimage up the Moldau to view the National Monument to Barrande—a simple tablet with his name, affixed to perhaps the finest section of Silurian rocks to be met with anywhere in the world. The collections of the departed pioneer in Bohemian Siluria are still packed up in the rooms he occupied, awaiting the completion of the National Museum destined to receive them.

Vienna.

From Prague to Vienna the route lies in part through the picturesque vales of Moravia, famous for their bone-caves; and the traveller leaves the quaint streets of the ancient Bohemian capital for the new promenades, parks, and palatial edifices built upon the site of the fortifications of the Imperial capital. Among the great buildings is the Hof Museum, still not arranged for public inspection, but rapidly becoming one of the finest in Europe. The best-lighted of the lofty rooms in the Geological Section is devoted to the grand Ettingshausen Collection of Fossil Plants, already in order and labelled, and each figured specimen accompanied by the published illustration. The other collections are arranged stratigraphically in the remaining

galleries, in many of the cases of which, it must be admitted, such delicate objects as fossil leaves could scarcely be seen to advantage. Not expecting to find the specimens accessible, the writer had unfortunately decided upon a very brief visit; but through the kindness of Dr. Theodor Fuchs and other members of the staff, the whole of the fossil fishes were made available for examination, and afforded some idea of the richness of the series. There is a large number of the Comen Cretaceous fishes, including the types described by Heckel; also many interesting specimens made known by Dr. Steindachner, the present Director of the Zoological Cabinet, who has unfortunately been compelled of late to desert Palæontology by the overwhelming amount of recent material absorbing his scientific energies. The Eocene Monte Bolca fishes comprise several unique specimens, among others the types of *Caranx ovalis*, *Calamostoma bolcensis*, *Solenorhynchus elegans*, *Urolophus princeps*, and *Trygonorhina de Zignii*, the last-named appearing to the present writer not to show the characters of the nasal valves requisite to separate it from *Rhinobatus*, The tail of a large Sword-fish from the Miocene of Malta is also interesting, and among earlier fishes, many noteworthy specimens occur in the collections from the Trias of Seefeld (Tyrol) and Raibl (Carinthia).

The enormous Austrian collection in the Geologisches Reichsanstalt, under the direction of Dr. Stur and Dr. Mojsisovics von Mojsvár, also comprises many vertebrate fossils of note. The remains of the Miocene "Leathery Turtle," *Psephophorus polygonus*, described by Prof. Seeley, occupies a small glass case here; and numerous fishes from the Austrian Tertiaries are being elucidated by Dr. Gorganović-Kramberger, of Agram. The greater portion of the skull of *Ceratodus* from the Rhætic will shortly be described by Dr. Teller; and among Triassic fishes the collection includes all the type-specimens from Raibl, described in Kner's well-known memoir. In the Paläontologisches Institut of the University, Prof. Dr. Neumayr has an interesting small series of Austrian fossil fishes; and in the Geologisches Institut, under Prof. Dr. Eduard Suess, are preserved the fragmentary remains of the Gosau Cretaceous Reptiles, described by Prof. Seeley.

University Museum, Munich.

Re-entering Germany, the University Palæontological Collection in Munich is the first attraction. There, in the midst of an enthusiastic group of students and naturalists engaged in original research, Prof. Dr. von Zittel adds to his numerous official duties the preparation of the great "Handbuch der Palæontologie," which has now reached the final volume. Another fasciculus will appear almost immediately, comprising the Teleostei and the Amphibia. The collection is so extensive, and contains so many type-specimens, that it is impossible during any brief visit to do more than rapidly glance over the more prominent objects. Among higher vertebrata, the series of mammals from Pikermi and the French Phosphorites is especially extensive, and has lately been turned to good account by Dr. Max Schlosser. Of reptiles and fishes, the collection from

the Bavarian Lithographic Stone is unrivalled, and comprises, among others, Wagner's *Compsognathus*, numerous Pterodactyles (including the wing described by Dr. von Zittel), several Lacertilians, many Selachians and Chimæroids, and still more Ganoids. Of great historical interest, also, is the Münster Collection—a series named and described in the early days of Palæontology, when specialists were almost unknown, and now requiring much revision. To these are added the originals of Schafhäutl's "Lethæa Bavarica," and many valuable isolated types; and the Museum is shortly to receive the huge Ichthyosaurs and other Liassic fossils from the Monastery of Banz. A nearly complete *Lariosaurus* from the Italian Trias has also lately been purchased; and important acquisitions from Solenhofen arrive continually. A week's study in a Museum of this kind leaves impressions never to be forgotten, and when added to one of the Professor's delightful Alpine excursions, such as it was the writer's privilege to join, the memory becomes particularly pleasurable.

Stuttgart.

The State Museum in the ancient capital of Würtemberg is another well-known centre of interest for those concerned with the Palæontology of the Vertebrata. Foremost in their unique character, perhaps, are the Reptiles and Amphibia, with a few Fishes, from the Würtemberg Keuper and Lettenkohle. Unfortunately, however, the reptiliferous beds have rarely yielded anything of note during recent years. Besides the remains of the Crocodilian *Belodon*, and the Dinosaurian *Zanclodon*, there is Dr. Kapff's large group of *Aetosaurus ferratus*, forming the subject of the memoir in 1877 by the present Director, Prof. Dr. Oscar Fraas. It is a marvellous fossil, of which no figure and description can give any adequate idea. The huge Stegocephalians from the same beds are also prominent, and will shortly be described in a memoir in course of preparation by Dr. Eberhard Fraas. The few fishes belong mostly to *Semionotus*; and it is almost certain that the supposed portion of the jaw of a Pterodactyle, described by H. von Meyer, pertains to a fish like *Belonorhynchus*. The Würtemberg Lias is represented by several Ichthyosaurs—including the specimen with three fœtal individuals, described by Prof. Seeley, and a recently-acquired paddle showing the integument, described by Dr. E. Fraas. There are also many Liassic fishes, and among these are some specimens labelled *Semionotus leptocephalus* in Agassiz' handwriting, showing that this species truly pertains to *Pholidophorus*, as already suspected by Dr. Oscar Fraas. A small example of *Palæospinax* is a novelty. Other fine fish-remains are exhibited from the Würtemberg Lithographic Stone of Nusplingen, including the so-called *Squatina acanthoderma*, which is probably identical with *S.* (*Thaumas*) *alifera*; and the collection of the distinguished author of the "Aus dem Orient" naturally contains many treasures from Mount Lebanon. Among Mammals there are two teeth of *Microlestes* from the Upper Keuper Bone-bed of Bebenhausen, Würtemberg; and Prof. Fraas also shows the originals of his classic work upon the Steinheim Fauna, besides many unique

examples of the Bohnerz mammalia, and Pleistocene bones too numerous to mention.

University Museum, Tübingen.

Amid the low rounded hills and broad fertile valleys of Swabian Würtemberg, lies the small city of Tübingen, the home of Professor Dr. Quenstedt. There, in a lofty old building upon the slopes overlooking the Neckar, it is a privilege and pleasure still to be able to meet the venerable Professor surrounded by the fossils illustrated in his works and memoirs extending over a period of not less than 53 years. The collection is almost exclusively local, and among Vertebrata contains many unique and typical specimens of great interest. From the Trias there are fine remains of *Zanclodon*, including a foot; also the natural mould of a Chelonian, lately added, perhaps identical with *Chelytherium obscurum*, H. von Meyer. From the Lias several well-preserved Teleosaurs and Ichthyosaurs are exhibited, some of the latter containing fœtal young; also an unrivalled series of examples of *Lepidotus elvensis*, described in the Professor's memoir, 40 years ago; and the dentition of a Cestraciont Selachian, closely allied to *Strophodus*, more recently made known under the name of *Bdellodus bollensis*. The Lithographic Stone fossils include the type of *Pterodactylus suevicus*, an example of *Rhacheosaurus*, the original group of teeth of *Notidanus serratus*, and many remains of Chimæroid and Ganoid fishes. Among Mammalia several fine series of teeth from the Bohnerz are exhibited, a few remains from Steinheim, and a few from the Würtemberg Pleistocene deposits.

Darmstadt.

When on the confines of Hessen-Darmstadt, the palæontologist is naturally attracted by the works of Kaup and Lepsius to the State Museum in Darmstadt. At present the collections are arranged in some of the rooms of the old Castle in the middle of the city, but, as almost everywhere, the demand for a specially constructed building is raised, and it is expected that before long the want will be supplied. Here, as might be supposed, the Tertiaries of the Mayence Basin are especially represented; and one of the most pleasing features of the collection consists in the large number of entirely new Mammalian fossils from Eppelsheim continually being acquired through the well-directed energies of the present keeper, Prof. Dr. Lepsius. Species known in the days of Kaup from little more than detached teeth are now represented by fine jaws and limb-bones; and the original type series begins to appear very small and insignificant. The collection of remains of *Halitherium* from Alzey and Flonhein is probably unique; and for this series, too, recent acquisitions await extrication from matrix in the cabinets of the Professor's study. The original remains of the remarkable Camel-like genus and species, *Merycotherium sibiricum*, from the Pleistocene of Siberia, are also here; and among reptiles may be noted the series of Mayence Crocodilian remains described by Ludwig in 1877. To the latter has lately been added the elongated snout of a large indi-

vidual, very suggestive of the genus *Rhamphosuchus* from the Siwalik Beds of India. Several undescribed fishes from the Mayence Basin are also represented; and among the latest additions is a portion of the trunk of a large rhombic-scaled ganoid, like *Lepidosteus*, from the Brown-coal of the neighbouring village of Messel.

University Museum, Strassburg.

Passing south to the University of Strassburg, we find the Professor of Geology and Palæontology also contemplating removal to more commodious quarters. The building of the new Geologisches Institut is yet only half erected, near to the great University Institutes devoted to Botany, Physics, and Chemistry. The palæontological collection under the care of Prof. Dr. Benecke is very extensive, and contains a few vertebrate fossils of note. The counterpart of the paddle of the Würtemberg *Ichthyosaurus*, already noticed at Stuttgart, is preserved here—a somewhat unfortunate separation of the halves of so unique a specimen. One moiety of the Jordan Collection of Lebach Permian fishes is also to be seen, the other moiety being in Berlin; and the types of Kner's *Conchopoma gadiforme* are thus separated, two of the series (the originals of pl. i. fig. 1, and pl. iii. of Kner's memoir) being preserved in Strassburg. Other specimens are two of the original teeth of the common *Otodus obliquus* from Sheppey, figured by Agassiz, and some of the types of *Carcharodon productus*, *C. leptodon*, and *C. megalodon*; also some Selachian teeth, figured by Gervais, from the Muschelkalk of Lunéville. The Director of the Natural History Museum, Dr. Döderlein, is at present engaged upon the study of a fine series of the Lebach *Pleuracanthus* (*Xenacanthus*); and the Assistant in Palæontology, Dr. Otto Jäkel, is in the midst of researches upon the microscopical structure of Selachian teeth, particularly those of the Alsatian and Silesian Muschelkalk.

Paris.

The great Museum of Natural History in Paris is too well known to require more than a passing notice. Prof. Gaudry's collections of fossil Mammalia from Pikermi and Mont Lebéron, a large series of Mammalia from the French Phosphorites, and Cuvier's Gypsum Mammalia, are to be seen; also the Gazzola collection of Monte Bolca Fishes, and some fish-remains from Mount Lebanon, collected by Prof. Gaudry. Conspicuous among recent additions are specimens of the Stegocephalian *Actinodon*, and some other vertebrates from the Middle Permian of Autun, lately described by the Professor. The public are also now well provided for in the new temporary Gallery of Palæontology, in which are exhibited the great skeleton of *Elephas meridionalis*, from Durfort (Gard), a reconstructed skeleton of *Mastodon angustidens*, from the Miocene of Simorre (Gers), and mounted skeletons of *Megatherium*, *Scelidotherium*, and *Glyptodon*, *Cervus hibernicus* and *Ursus spelæus*, besides a slab of gypsum with a nearly complete skeleton of *Palæotherium magnum*. With these are placed four examples of *Dinornis*, and several well-known reptilian fossils, in addition to a few of the larger Monte Bolca fishes.

Boulogne.

The Museum of Boulogne is presided over by Dr. H. E. Sauvage, the Director of the Station Aquicole, and is especially rich in historical antiquities, mainly discovered in the immediate neighbourhood. A typical collection, however, represents local geology and palæontology, and the vertebrate fossils have been described in some of the well-known works of the Director. A Portlandian *Rhinobatus* (*Spathobatis*) seems to be scarcely distinguishable from the great *Rhinobatus mirabilis* of the Solenhofen Lithographic Stone; and the Kimmeridgian fossils are very like those of England.

In concluding these brief notes, the writer would once more express his warmest thanks to all whose cordial receptions everywhere added to the enjoyment of the tour. In the Scientific World there is certainly no nationality; and a practical interest in any particular branch of study is an amply sufficient passport to all scenes of scientific activity, wherever they may be.

IV.—The Volcanoes of Barren Island and Narcondam in the Bay of Bengal.

By Prof. V. Ball, M.A., F.R.S., F.G.S.,
Director of the Science and Art Museum, Dublin.

Second Notice.

About nine years ago I contributed to the pages of this Magazine,[1] an account of the two above-named volcanoes, which was founded on observations made during brief visits by myself in the year 1873, and on the published records of visits by previous observers. My present object is to draw attention to information which has since then been acquired regarding them.

Barren Island, Lat. 12° 15′, Long. 93° 50′.

As Barren Island affords a typical example of a volcano having an encircling outer crater with an inner cone, it has attracted the notice of many authors who have written either on general geology or on special volcanic phenomena, and it has often been described by them; but, as I pointed out, their descriptions have, unfortunately, interwoven with the facts a certain amount of myth, the origin of which I was, however, enabled to indicate. It was due to the misconception by Von Buch of the meaning of the English description by Blair, from which he quoted, that he gave currency to the statement that the sea had access to the interior of the old crater and surrounded the inner cone. For this statement there is not a shadow of historical evidence, the records so far as they go prove the contrary. At the same time it very possibly may have been the case at a prehistoric period in the life of the volcano.

In the year 1884, what may be described as the first exhaustive geological and topographical survey of these two volcanic islands was made by Mr. F. R. Mallet and Captain Hobday, who spent nine

[1] Geological Magazine, Vol. VI. 1879, pp. 16–27.

days at Barren Island and four at Narcondam. The results have been published by Mr. Mallet,[1] and his paper gives a most interesting account of both islands, which is accompanied by several valuable maps and sections, all of which may be said to supersede what has been previously published.

In referring to the subject again, I desire to point out, in the first place, that I quite agree with Mr. Mallet that the crater at the summit of the cone on Barren Island as he saw it in 1884 was practically in the same condition as when I saw it in 1873, and that consequently there has been no active eruption during the interval of eleven years.

Unfortunately I cannot now definitely account for the fact that there is a difference in the bearings of the larger sides of the crater, as given by Dr. Playfair and myself, from those ascertained by the recent survey. It is possible that I may have quoted Dr. Playfair's bearings either by mistake or because my own memorandum had been lost. Be that as it may, the elliptical hollow as now described and represented corresponds in all its details with my recollection of what it was when I saw it.

We may indeed, I think, with perfect safety, push back the period of the quiescence of the volcano still further. There is before me an original copy of a photograph taken by M. Mellitte for Dr. Mouat, whose signature it bears and the date, Dec. 1857. It represents the cone with its characteristic points exactly as it is shown in the lithograph from a photograph which is given in Mr. Mallet's memoir. During this period of 27 years, that is to say, up to 1884, the only observed manifestation of internal action has been afforded by the outpouring of steam and sulphurous vapour from a portion of the edge of the crater.

In the *Bombay Times*, during July, 1852, the volcano is said to have been described "as very active." I was unable, when in India, to verify this statement by reference to the original. Possibly the paragraph itself might show whether this was only an exaggerated way of describing the issue of steam from the summit. If the volcano was really in a violent state of eruption in that year, there should be, one would suppose, abundant record of it in the logs of passing vessels.

Nothing can be more conclusive as to the cooling down of the lower parts of the lava which occupies the valley between the old outer crater and the cone, and perhaps it may be added the exhaustion generally of the energy of this volcano, than the records of the temperatures of the hot spring as observed during the period from 1832 to 1884. In 1832 it was described as almost boiling; in 1857 (Drs. Mouat and Playfair) it was too hot to be borne by the hand, their thermometer was only capable of measuring up to 140° F.; in 1858 (Dr. Liebig) almost boiling; in 1862 (Rev. C. Parish) scalding hot; in 1866 (Andaman Committee) 158°—163°; in 1873 (V. Ball) 130°; in 1884 (F. R. Mallet) 106°—116°. These observations are not sufficient to establish the rate of cooling, though

[1] Mem. Geol. Survey of India, vol. xxi. pt. 4.

The conical shape and abrupt appearance of the island, in the middle of the sea, were probably sufficient to cause it to be regarded as a volcano by voyagers, as none of them refer to having witnessed any of the ordinary volcanic phenomena, and but very few ever actually landed on the island.

As all recorded dates of the periods when these islands were seen by travellers are of considerable interest, the following should be added to those given in my previous paper. According to Col. Yule Naroondam is first referred to by Linschoten in the year 1598 under the name of *Viacondam.* In Surgeon Finlayson's account of Crawfurd's mission to Siam we find the following under the date Dec. 3, 1821:—"On the following morning, at sun-rise, we were within sight of Narcondam, an island apparently several miles in diameter, in form and shape a perfect specimen of the volcanic cone, which we calculated to be about two thousand five hundred feet above the sea. We were at too great a distance to entertain a hope of landing on it. This island from its height, its solitary existence in a wide sea, and its singular and beautiful form constitutes a very striking object."

Dimensions of Narcondam.

Maximum diameter of Island	$2\frac{1}{2}$ miles.
Circumference	$6\frac{1}{2}$,,
Height	2330 feet.

V.—Sections of Bagshot Beds at Finchampstead, Berks.

By the Rev. A. Irving, D.Sc. (Lond.), B.A., F.G.S.

Considering the interest that has been awakened of late in the Bagshot Beds of the London Basin, and the paucity of good sections open to the light of day exhibiting any considerable vertical range of those beds, it has occurred to me that a fuller description of these Finchampstead sections may be of sufficient interest to students of Tertiary geology to justify its appearance in the pages of the Geological Magazine.[1] In the task we have before us of attempting to work out the old physical geography of the Lower Thames Basin in later Eocene times, every *contribution of facts* (by no means the easiest part of inductive science) must be welcome to students of the subject. The problem was sketched in its outlines and bequeathed to his successors by the versatile mind of the late Prof. John Phillips, F.R.S. "In considering these remarkable strata (he says,[2] of the London Bagshot Beds), which were accumulated in a period so near, geologically speaking, to our own, we are presented with problems of great interest, which, if they can be solved, will have more than local application. Whence came the materials, the clay, the sand, the pebbles? In what direction, by what forces

[1] The Editor much regrets the delay which has arisen in the publication of this paper.

[2] "Geology of Oxford and the Valley of the Thames," p. 450. There is a slight error on the same page: "the highest land which [the Bagshot beds] reach in this area" is the plateau of Cæsar's Camp and Beacon Hill south of Aldershot, not Hampstead Heath. He is, I believe, also in error in ascribing the 'flint-pebbles' to river-action so far as the rounding of them is concerned.

urged? What were the tracts of sea and land, how deep the water, how high the land? What is the explanation of the appearance of fluviatile shells among oceanic exuviæ?" The subject as thus sketched is, it will be admitted, one of far wider and more general interest than such minor questions (which crop up in connexion with it) as can be settled by the ordinary rules of stratigraphy. It is easy to indulge in premature speculation on the subject; but sound inductive science requires the slow and patient antecedent process of accurate observation, and a record and comparison of facts. While feeling our way to such ultimate conclusions as may be established, not on an aggregation of opinions or 'views,' but as rigid inductions from facts, many minor inductions must of course be made and criticized, some of which will have to be abandoned in the light of fuller knowledge. It is therefore desirable that, when exceptional facilities occur (such as were presented to Prof. Prestwich some 40 years ago at Goldsworthy), a careful record of the facts should be preserved.

The present paper will be mainly occupied with the detailed description of some sections at Finchampstead, Berks, in which the whole complexus or group of the Middle Bagshot Beds is exposed. One or two of these sections have been referred to on previous occasions by myself[1] and by other writers,[2] and in one instance a sectional drawing has been given.[3] Convinced, however, that that was not exactly in accordance with the facts, the author (Oct. 1886) got some rather extensive excavations made in the old clay-pit on the north side of Wick Hill near Ninemile Ride, and the section thus obtained, when correlated with the open section in the California brickyards on the other side of the road, the levels being taken from one spot to the other (a distance of 330 yards), was found to furnish the details given in the figured section of this paper (p. 411).

In these combined sections in the Wick Hill clay-pit, and in the California brickyard,[4] the Middle Bagshot beds are seen to attain a thickness of about 50 feet as compared with quite 70 feet in the well at Wellington College. This diminution is entirely at the expense of the green-earth series (Nos. 7 and 8 of the latter section). This, as I have shown in recent papers read before the Geological Society, is found to be the case generally, the 41 feet of the well-section dwindling down to 20 feet in a distance three-quarters of a mile to the north, the attenuation of those beds being complete before we reach Easthampstead. In this section they may be represented by only 16 feet, while the upper clay-bed (9 feet thick at Wellington College, and 6 feet thick in the Station cutting) is here seen developed to 10 feet, the boundary-line between it and the bed next below being drawn where patches of green earthy sand first appear. This is not the only case in which this bed is found to assume a greater thickness as we approach the London Clay; at

[1] Q.J.G.S. vol. xli. p. 504. Wick Hill is named on some maps 'Upwick's Hill.'
[2] Q J.G.S. vol. xlii. p. 408.
[3] *loc. cit.* fig. 2, p. 409.
[4] Sections P and Q of my last paper (Q.J.G.S. vol. xliv. p. 172).

Swinley (*e.g.*), where its horizon is determined by its relation to the Upper Bagshot Sands of Tower Hill, and to the dark green sand which is found everywhere beneath it in the trial holes which have been made in Mr. Lawrence's brickyards, it attains a thickness of 12 to 14 feet.[1] The increased argillaceous character of the green-earth beds in the Wick Hill section, to such an extent as to almost obliterate their green earthy character, by the development of strong clays, is definitely anticipated in the intermediate country in the direction of Wellington College.

Thus a strong unctuous grey clay is found in thin beds intercalated with the green earths on the north side of Wellington College estate; and in what is known as Holloway's Land on the north side of the Duke's Ride, the clays of the green-earth series are so considerably developed, that a few years ago they were worked for bricks. They are partly grey, partly purplish clays, with numerous included patches and small layers of the typical green earthy sands. The upper clay-bed in the Wick Hill section has more green earthy sand in proportion to the clay-seams than it has in the cutting north of the station; but both the green sand and the clay-seams are of the same quality, and the physical character of the bed is the same in both sections. More extended observation of the Bagshots has led me to regard the upper 5 feet or so of coarse loose sand, with a few strongly-marked clay-seams in the California sub-section, as not a true Bagshot Bed at all. It is much less compacted than they are; it has a strong pseudo-dip to the north, as is seen again in the excavation by the rifle-butts; and in one pit-face I measured lately a dip of $2\frac{1}{2}°$ W.N.W. It is, I believe, nothing more than a deposit formed by the run of the hill to the south in post-Bagshot times.[2] The section-diagram and the marginal descriptions of the several beds are made from measurements and notes taken on the afternoon of the day on which the clean excavation was made for me in 1886, and from the open clay-pits in the brickyard. The lower part of the California sub-section is constructed from data furnished in two wells at the engine-house.

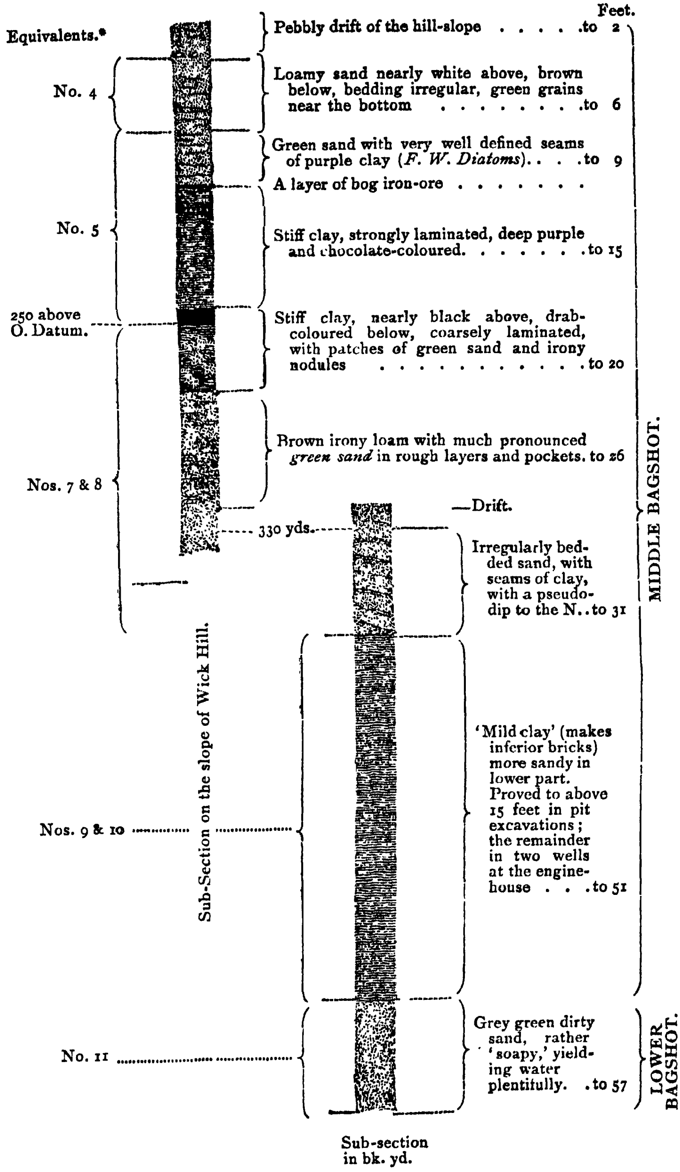
There being good vertical sections at right angles of the lower clay-and-laminated-sand-bed in the open pits in the brickfield, the absence of any measurable dip in it may be predicated with some degree of certainty. Yet a considerable dip would be required in order to bring them into the Lower Bagshot, if we take into account the position of the green earth series (20 feet exposed) with the clay-bed above it at Heath Pool, the position of the Upper Bagshot

[1] For fuller details see Section L of my paper on "The Stratigraphy of the Bagshot Beds of the London Basin," Q.J.G.S. May, 1888.

[2] A similar 'run of the hill,' with a pseudo-dip 'rather north of east' on the side of Thorn Hill, Aldershot, has been wrongly noted as a dip of the Bagshot beds there (Q.J.G.S. vol. xlii. p. 410). Here, however, the character of the deposit is more suggestive of rearrangement in a shallow lake; possibly on the margin of the Thames-valley arm of the great extra-morainic lake of the late Prof. H. Carvill Lewis, whose loss we deplore. To add anything to the sketch of his character at the end of the article in "Nature" (August 9th, 1888) would be an attempt to 'gild refined gold.'

SECTION OF MIDDLE BAGSHOT BEDS,

SHOWING DETAILS OBTAINED DURING EXCAVATIONS ON THE NORTH SIDE OF WICK HILL, FINCHAMPSTEAD, AND IN CALIFORNIA BRICK-YARD.



* (Nos. as in Section fig. 1, Q.J.G.S. vol. xli. p. 494.) The bracketing on the left-hand side of the figure must be regarded as tentative. In Q.J.G.S. (vol. xliv. p. 172) reasons are given for assigning the stiff, chocolate-coloured clays to bed No. 7.

Sands in the lane a little way to the south below Ridge Farm, and the position of the whole Middle Bagshot group, on the other side of Ninemile Ride (Q.J.G.S. vol. xliv. pp. 171, 172). These facts so strongly substantiate the mapping of these California beds as the *basement-beds of the Middle Bagshot*, that their true horizon can scarcely be a matter for further discussion.[1] The 20 feet of clays and loams, with included irony nodules, which are here recognized as constituting the basement-beds of the Middle Bagshot, seem to mark the most persistent and constant horizon through the whole Bagshot district; they are as distinctly recognizable at their southern outcrop at Aldershot, Ash and Woking, as they are on this northern side.[2] In every case where they do not overlap the Lower Bagshot, and rest directly upon the London Clay, they are succeeded downwards by a fine quartz sand, generally containing minute flakes of glassy silica. In most of the well-sections known to me on the northern side of the district, this is a dirty carbonaceous sand, generally blackish with a tinge more or less of green, and it usually contains lignite and pyritous material, the latter often cementing the sand into hard nodules. On the other hand, where it crops out at the surface, it occurs as a much cleaner sand (in places almost a 'silver sand'), from long exposure to the oxydizing action of atmospheric waters. This succession, which is seen in the wells at California (see section), is seen in the banks of King's Mere, and near the railway about three-quarters of a mile to the east; it occurs again in the valley three-quarters of a mile north of Wellington College, where I have lately proved the base of these loam and clay beds of the Middle Group by excavation; at exactly the same altitude (215 O.D.); it is seen at Wokingham, in the railway-cuttings at Buckhurst and Bracknell, in the Pinewood Brickyard by the Ninemile Ride ($1\frac{1}{2}$ miles east of California); it was proved in a well at Longmoor, about a mile to the west, some years ago, and in a well at the village school, Finchampstead, which was dug two years ago. At the western end of Finchampstead Ridges we can trace the succession of the beds by a number of road-sections, from a section in the Upper Bagshot at North Court (300 O.D.)[3] down through the pebble-bed (at about

[1] Q.J.G.S. vol. xli. p. 504; also *ibid.* vol. xlii. p. 408. There is, moreover, nothing in the known structure of the Lower Bagshot Beds of the deep-well sections of this northern side of the district to warrant the assignment of those beds to that group.

[2] I have traced and mapped for the most part their outcrop along the northern flank of the Bagshot area from Farley Hill south of Reading to Englefield Green (see last paper, Q.J.G.S. May, 1888).

[3] Recently a new road-cutting 8 to 10 feet deep, close by North Court, has given us a capital section of the Upper Bagshot Beds. The beds are of the usual character in the lower part of the section, but these pass upwards by a steady gradation into a very stiff irony 'leathery' loam, in which occur numerous pipes and small layers of loose sand intermingled with many black and some green grains. They are infillings in all probability of the holes and tubes left by the decay of the roots and rhizomes of plants that grew *in situ*, when, after the close of the Bagshot period, the ancient marine estuary became reconverted by an ordinary silting-up process into land. Emptied of the contained sand, these holes and tubes bear a striking resemblance to those often seen in Sarsen stones (cf. remarks by the author, Proc. Geol. Assoc. vol. viii. p. 155).

260), the upper clay, the green earths (at East Court) and the lower clays and sands of the Middle Bagshot basement-bed, which is seen in small road-sections cropping out below the green earths (the junction being exposed in section continuously for about 20 yards), till we come to about 210 (O.D.) at the village school. Here the well just mentioned gives the following sections:

a.	Yellow stiff ferruginous clayey (laminated) sand	10 feet
b.	Greenish-black sand with pyritous nodules	5 ,,
c.	Running bluish quartz sand with lumps of stiff black clay	5 ,,
		20 feet

The succession of the whole Middle Bagshot series immediately above leaves no room for doubt as to the horizon here. At Longmoor (the particulars of this well were given me by the man who dug it) the section is as follows:—

a.	Gravelly drift	1 foot
b.	Soft loamy yellowish clay, "like that now dug in the California pits, but not quite so strong."	3 feet
c.	Soft loose sand	12 ,,
		16 feet

This is near the outcrop of the London Clay.

In my last paper (Q. J. G. S. May, 1888) particulars are given of the structure of the Church Hill which forms the westernmost spur of Finchampstead Ridges, and of the stratigraphical relation of the beds in the Bearwood Hills to those in that hill, from which I still maintain that the recognition of the pebble-bed horizon in the Barkham pit, and in Coombe Wood, as marking the base of the Upper Bagshot, fits in well with the structure of the adjoining country. This could easily be shown in a section drawn about north-west from Wellington College, so as to include the well-section there, the section at the station, and that of a well dug lately (1886) behind the Wellington Hotel, the section in the pinewoods near Heath Pool,[1] and the Wick-Hill-California section.

The facts described in this paper, and in those which have recently appeared in the Geol. Society's Journal, admit of one simple explanation, and that is a gradual (though not uniform) attenuation of the Lower Group of quartz sands (ninety-five feet thick at Wellington College) and of the green-earth beds of the Middle Group. In consequence of this, the gradients of the basement clayey beds of the Middle Group, the base of the Upper Group, and the surface of the London Clay, form a triad of horizons which approximate nearer and nearer to one another as we trace them to the north; and, as a further consequence of this, beds of higher horizons overlap in places those of lower, and rest upon an eroded surface of the London Clay along the line of country by Bearwood, Wokingham, Buckhurst and Bracknell, so that we have pretty clear indications of the northern shore-limit of the ancient Eocene estuary, traces of its affluents being recognized at Ascot and Wokingham.

Supplementary Note.—In a former paper (Geol. Mag. Dec. III.

[1] Section O (Q.J.G.S. vol. xliv. p. 171).

Vol. II. p. 18) the author spoke of the well at Finchampstead Rectory as penetrating the Upper Bagshot Sands, mainly on account of the absence of green earthy sands in the section. In the face of the facts since brought to light in connexion with the stratigraphy of Finchampstead Ridges, this view is seen to be untenable. The absence of any noticeable quantity of green earthy sands in the well is probably accounted for by such a lateral variation of the lithological character of the Middle Bagshot beds as has been noticed in this paper at Wick Hill; and when this is taken into account, it will be seen that the relegation of the beds in the hill on which the Rectory stands to the *Middle* Bagshot does not affect materially the argument of the previous paper, which dealt merely with the question of Water Supply. It is the basement-bed of the Middle Group which forms the water-bearing horizon in the hill on which the Rectory stands, and the surrounding country is chiefly indebted to the clayey beds of this group for its fertility and the charms of the landscape.

VI.—On Some Rock Specimens from Somali Land.

By Miss C. A. Raisin, B.Sc.

As not much appears to be known about the geology of Somali Land, a description of some specimens, forwarded by Col. M. Gosset, and collected by Capt. King, the Political Officer at Zaila, may be of interest. These specimens were sent to Prof. Rupert Jones, who requested Professor Bonney to undertake the description of them. As, owing to unexpected pressure of work, he found it difficult to spare time for this purpose, he placed them in my hands, and the work has been done at University College under his superintendence.

The collection of rocks was made during an expedition from Zaila to Mount Eilo. Zaila is on the northern coast of the Somali Land, and Mount Eilo lies to the south-east, on the northern frontier of the Gadabursi country. The account, sent by Capt. King, gives us the following particulars of the district. The hills consist mainly of limestones, which are usually crystalline, and somewhat fissile. One variety is a fine-grained, hard, lithographic stone, which is grey, yellowish-grey, or reddish-brown in colour, and breaks with a marked conchoidal fracture. Boulders of this stone occur abundantly in the river-beds, and some of the slabs appeared as if they had been artificially quarried for lithographic purposes. A sandstone generally of a reddish-yellow colour is associated with the limestones. It is hard, fine-grained, and massive, and is well adapted for grindstones. The hills exhibit a clearly marked stratification, and the beds dip usually at an angle of from 20° to 25°.

Felspar and hornblende-bearing rocks [a porphyrite and a hornblende-diabase], and one which is greenish and compact [an epidosite], occur near the foot of the hills, while outcrops of mica-schist and gneiss are exposed in the valleys, where we find also abundance of fragmental quartz.

Over sheltered valleys, such as the Koton, there is spread a thick covering of rich soil. The main valleys are long, and have a gentle slope; and in these, large boulders rarely occur, but they are common in the short and steep ramifications, and the exposed slopes of the hills show signs of very extensive denudation. The detritus, thence derived, has been carried down, until its transport was checked by the sea and by the fringe of coral reefs, and the deposit then accumulated backwards, building up the immense alluvial plain in the form of a long, narrow, and scarcely perceptible basin, parallel to the coast-line. The light, argillaceous portion of the detritus reached the coast first. It was there rapidly deposited and formed an impermeable stratum, which retains both the local rain water and that which is absorbed further inland. As a result, abundance of water is obtainable all along the coast, from the Gulf of Tajurra to Bulhar, within three or four feet of the surface, while in the alluvial plain further inland the wells have to be sunk to a considerable depth. One of the circumstances, which tend to maintain the water supply in the coast basin is that the rainy seasons above and below the Ghâts do not coincide. In illustration of this, Capt. King mentions that he saw the Taknota river, when in a state of flood, discolouring the sea to a distance of more than a mile, although no rain had fallen near the coast for some months.

The specimens collected by Capt. King have been examined, and slides for the microscope prepared from the most interesting.

Igneous Rocks. (1.) *Porphyrite.*—This rock, of a dingy-brown, containing porphyritic felspars, chiefly plagioclase, and other crystals possibly pseudomorphs after pyroxene, gives good illustration of the replacement of felspar. Granular epidote has developed, generally from the heart of the crystal, and forms pale-green patches, well marked even in the hand specimen. In one felspar, there is a fan-shaped group of chlorite; apatite crystals are also present, one of which seems to have been corroded by intruding portions of the ground-mass.

(2.) *Hornblende-Diabase.*—The crowded crystals of large green hornblende are very dichroic, giving high tints with crossed Nicols (purples and reds), but they pass by a gradual transition to lighter-coloured less dichroic patches within, and thus recall the more abrupt variation from brown to green hornblende in the Little Knott rock.[1] It would seem that a secondary change has attacked the mineral, but has not completely spread over the interior. There is a tendency to an orientation in the hornblende cleavages, and the crushed and schistose structure of the rock may well be the result of pressure, which has acted on what was possibly once a gabbro.

(3.) *Granite.*—This granite, whose locality is not given, may perhaps have occurred in association with the metamorphic rocks of the valleys, and may contribute to the fragmental quartz, which is said to be so abundant there. The felspar is chiefly microcline; and, included both in it and in the quartz, is a dark green metallic-looking mica, so small in amount that the rock is almost a binary granite.

[1] Q.J.G.S. 1885, vol. xli. p. 512, pl. xvi. fig. 2.

In the quartz, along continuous surfaces, are rather large fluid cavities with moving bubbles. The granite seems somewhat disintegrated; the quartz grains, and, at places, the felspar, are coated with a bright red deposit. Some of this ferruginous substance appears under the microscope minutely pisolitic, and the small concretions are sometimes banded concentrically like spherulites.

Metamorphic Rocks. (1.) *Gneisses.*—One specimen is a white micaceous gneiss, with small garnets. From the appearance of the rock, Professor Bonney has suggested that it may possibly have been once igneous, although there is now an evident foliation, and the gneiss has suffered contortion since the foliation was acquired.

In a pale red or flesh-coloured gneiss, the quartz is ranged in streaks very suggestive of the action of pressure. The felspar is mainly plagioclase, with possibly some microcline, and either exhibits a kaolinized condition, or seems to pass to a clear mineral with lines like the distinctly marked cleavages of kyanite, suggesting the possibility of the formation of clear pseudomorphs similar to those noticed by Prof. Bonney.[1] White mica seems to have developed in places at the expense of the felspar.

A banded hornblendic gneiss contains hornblende, which is very dichroic and possibly of two varieties. It is replaced in the paler bands of the rock by brown mica, associated with quartz, and also with felspar, which may be partly kaolinized along certain of the twinned laminæ. Small irregularly formed garnets occur, salmon-pink in colour, within a cloud of kaolinized substance and associated with flakes of biotite, as if they had formed from original felspathic material by the addition of iron and magnesia, while the brown mica was developed in connection.

(2.) *Talc Schist.*—This specimen seems to have been artificially cut, as if the rock may be used as a kind of potstone. Under the microscope, the slide exhibits an interfelted mass of talc, together with a pale apple-green mineral, which is sometimes very dichroic, and would agree with prochlorite in its softness. Some magnetite occurs, and a reddish iron glance in such quantity that the section has a brownish colour. The chlorite has much the appearance of a pseudomorphous formation after some mineral, very probably biotite, and it helps to give the orientation of the slide. The foliation appears to have undergone subsequent disturbance, amounting to a crumpling and even an approach towards an "ausweichungsclivage."[2]

(3.) *Epidote Schist or Epidosite.*—Said to occur near the foot of the hills, and it would probably belong to some part of the earlier series of rocks, which form the foundation of the higher ground. The specimen consists mainly of epidote, the quartz being probably not more than 10 per cent. of the whole rock. The epidote is mostly granular, but some of it is in larger crystals, which exhibit cleavage. The quartz grains are drawn out in the direction of the general orientation and sometimes ranged, almost in single file, in thin parallel bands. A few small crystals of hornblende occur.

[1] Q.J.G.S. 1878, Pre-Carb. Rocks of Charnwood, part ii. p. 215, note.

[2] "An advanced stage of minute puckering, some or all of the surfaces of contrary flexure having become shear-planes." (*Teall's Petrography*, p. 424.)

(4.) *Quartzite.*—This is formed of very well rounded grains cemented by crystalline silica, and is thus similar to the specimen recently described by Professor Bonney from near Ightham.[1] The cement consists mainly of crystals projecting outwards, and ranged in successive layers, which are separated by dusty lines. The wider interstices are filled in, towards the interior, by clear chalcedonic granules, the deposit being sometimes completed in the centre by a brown opaque material. The grains of the quartzite are mostly simple, but sometimes composite, and they contain rutile-like needles, and lines of cavities with moving bubbles. The quartz may appear very dirty, or it may contain only few enclosures, but in several examples these cease along a narrow marginal zone, which, therefore, probably represents siliceous cement deposited in crystalline continuity with the original grains.

Sedimentary Rocks. 1. *Grits and Sandstones.*—One specimen of sand, which consists of well rounded grains, is labelled "red earth used for dyeing." The quartz grains are large, and are coated with ferruginous deposit, and seem thus not unlike the red sands of the Arabian Desert described by Mr. Phillips.[2] Fragments which are more angular form the constituents of a coarse, claret-coloured grit, and of a very strong brown sandstone, which was obtained from Mount Eilo, and is probably the one mentioned as suitable for grindstones. In all the sands and grits, the quartz is more or less coated with a ferruginous substance, which is not unfrequently a kind of pisolitic deposit, similar to that described in the granite. In some of the specimens there are quartz pyramids connected with the grains, which recall the appearance of the additive crystals figured by Mr. Phillips.[3] Besides quartz, the slides contain fragmental felspar, often plagioclase, also films of brown mica, and occasionally a hornblende or tourmaline fragment or a garnet.

2. *Limestones.*—The lithographic stones, as well as other of the limestones, have a very compact character, as is illustrated also by a specimen from the floor of Eilo cave, "polished by the passage of animals over it." (1.) From Mount Eilo. This pale buff-coloured limestone is as compact in character, but has the appearance of a fissile structure. It is in a partially crystalline condition, but with much admixture of earthy material. This limestone, and some of the lithographic stone with most marked conchoidal fracture, yielded only slight traces of fossils, but in slides prepared from two specimens, organic remains were well able to be identified, although they were less clear in one of the two rocks, which appeared to have undergone greater dolomitization. These slides, with my conjectures as to the identification of the fossil forms, were submitted to Prof. Rupert Jones, and the following is a list modified in accordance with the opinion he kindly expressed.

(2.) Limestone, fourteen miles south of Bulhar. This contains

[1] Geol. Mag. July, 1888, Figure on p. 299.

[2] Q J.G.S. 1882, vol. xxxviii. p. 111.

[3] Q.J.G.S. 1881, vol. xxxvii. "On the Constitution of Grits and Sandstones," pl. ii. figs. 1, 2, 3, 5.

many obscure Foraminifera, such as *Amphistegina* (?); and there are also remains of Polyzoa (?).

(3.) Limestone from Eilo. The slides of this rock exhibit:—Fragments of Lamellibranch shells, of Polyzoa, of (?) a plate of an Echinoderm, and Gorgonia-like spicules.

Foraminifera:—*Lagena*, *Globigerina*, *Textularia* (common), *Planorbulina*, *Rotalia*, *Miliola*, sections of specimens having affinities (?) with *Miliolina*, and rather *Trochammina*-like in form.

The general facies of this fauna is characteristic of late Cretaceous and of Tertiary formations, but if the forms doubtfully identified as *Amphistegina* belong to that genus, its occurrence, fairly abundant, would rather suggest that the limestone may be of Miocene age, and thus possibly contemporaneous with that of Socotra.[1]

From certain miscellaneous specimens, we may infer that flint and chert, containing traces of organic remains, were formed in connection with the calcareous rocks. The deposition of a ferruginous material is everywhere emphasized in sands and grits, in the coating of larger pebbles, and in irony concretions, recalling the description of a neighbouring locality where the ground was said to look as if strewn with iron slag.[2]

The district, illustrated by these rock fragments, is evidently one in which the foundations of the hills are composed of gneisses and schists, which are laid bare in the valleys, possibly in association with granite. Among these rocks, there are evidences of the action of pressure, and thus, in the higher ranges further inland, this gneissic series may be raised to a greater elevation and may form a larger part of the mass, as in the place where Sir F. Burton describes walls of rock full of glittering mica.[3] The central massif would be concealed beneath gently stratified sedimentary beds. Some of these are grits and sandstones, which mark the results of a denudation of older crystalline rocks, others are limestones, sometimes Foraminiferal.

The crystalline series is found to the eastward, as shown in the sections from Somali Land published by Dr. A. T. de Rochebrune[4] from notes brought back by M. Révoil, and still further eastward in the Island of Socotra.[5] Northward, similar rocks occur in Abyssinia[6] and Egypt, and in the peninsula of Sinai. Sandstones and limestones have a similarly wide extension, although further evidence is needed to fix the exact age and correlation of these formations in the Eilo district. Some of the sandstones seem, lithologically, rather like those, which Dr. Rochebrune compares with the older sands of Nubia and of Adigrat; the overlying calcareo-argillaceous rocks he identifies by their fossils as of Neocomian age. Thus the rocks, described in this note, vary in some details from those of neighbouring localities, yet bear out, on the whole, the inference of Professor Bonney as to the wide extension which has characterized former geological conditions in North-eastern Africa.

[1] Phil. Trans. 1883. [2] "First Footsteps in Africa," p. 391.

[3] "First Footsteps in Africa," p. 395.

[4] Faune et Flore des Pays Çomalis, G. Révoil, 1882 (Observ. Géol. Dr. A. T. de Rochebrune). [5] Phil. Trans. 1883.

[6] Geology and Zoology of Abyssinia, W. T. Blanford.

VII.—Note on *Eurypterus* from the Carboniferous.

By Henry Woodward, LL.D., F.R.S., V.P.G.S.,
of the British Museum (Natural History).

IN the Geological Magazine for November last (Decade III. Vol. IV. p. 481, Pl. XIII.) I gave a brief description of a new species of *Eurypterus* from the Lower Carboniferous Shales, Eskdale, Scotland, which I named *Eurypterus scabrosus.*

I referred to other Carboniferous forms, and briefly mentioned one from the Lower productive Coal-measures, Darlington, Pennsylvania, U.S.A., figured as a *woodcut* only in the American Phil. Soc. Proc. vol. xix. p. 152, 1881.

I was not aware at that time that my friend Professor James Hall, of Albany, had printed a "Note on the *Eurypteridæ* of the Devonian and Carboniferous Formations of Pennsylvania." [Extracted from Report of Progress PPP, Second Geological Survey of Pennsylvania. 8vo. with six plates, Harrisburg, 1884; *printed in advance.*]

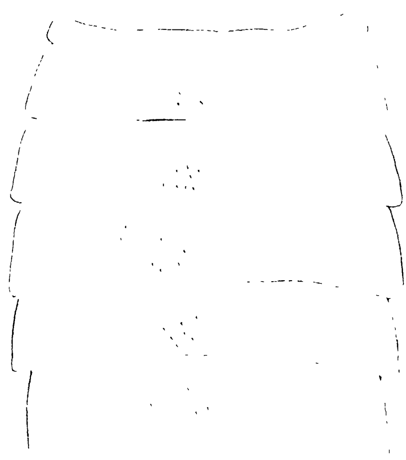
Having, through the kindness of the author, been favoured with a copy of this memoir, I hasten to remedy the omission in my paper referred to above, and to state that Professor James Hall has fully described and figured this Coal-Measure *Eurypterus* from Darlington under the name of *E. Mansfieldi.* Both in the form of its appendages and its size *E. scabrosus* is quite distinct from Hall's *E. Mansfieldi,* the latter being not more than nine inches in length, whereas the former measured, when perfect, probably not less than 20 inches. *E. scabrosus* was, moreover, furnished with long and slender bluntly-spinose appendages, but in *E. Mansfieldi* the palpi terminated in sharp recurved spines, closely resembling the earlier U. Silurian forms both in its palpi and swimming-feet.

Prof. James Hall devotes 24 figures to the illustration of this species; he also figures and describes three others (*E. potens, E. stylus,* and *E. Pennsylvanicus*) from the same locality and formation as *E. Mansfieldi. E. stylus* is a much smaller form, only about half the length of the former. *E. Pennsylvanicus* is only known by a detached carapace, and *E. potens* by some detached portions. Professor James Hall also adds an important note on *Eurypterus* (*Anthraconectes*) *Mazonensis,* Meek and Worthen, from the Coal-measures of Grundy Co., Illinois (see Amer. Journ. Sci. vol. 46, p. 21, 1868: also Geol. Surv. of Illinois, vol. iii. (Geology and Palæontology), 1868, p. 544, woodcut figure). This, as Hall very correctly points out, is no doubt a true *Eurypterus,* and the slight differences pointed out by Messrs. Meek and Worthen do not seem to justify the placing it in a distinct genus.

Prof. Hall figures a second specimen from Mazon Creek, which he believes to be *the actual counterpart* of Meek and Worthen's specimen, and points out how closely it agrees in many respects with *E. Mansfieldi,* the differences being really only of specific value.

The same author also figures and describes a very complete but headless body of a *Eurypterus* from the Chemung group (Upper Devonian) of Warren, Pennsylvania (plate iii. p. 30, op. cit.), which

he names *E. Beecheri.*[1] From the presence of parts of two long slender, ridged, non-spinose appendages associated with the body in the position which would have been occupied by the swimming-feet, I am led to surmise that this may possibly prove to belong to the genus *Stylonurus*; but I offer this suggestion with extreme caution and reserve, well knowing the great care and vast experience of Prof. James Hall in dealing with this group of ancient Merostomatous Crustacea.



Body-segments of *Eurypterus Wilsoni*, H.W. (natural size), Coal-measures, Radstock, Somerset.

Before concluding this note, I desire to call attention to a very interesting discovery made by Mr. Edward Wilson, F.G.S., of the Bristol Museum, of a part of the body of a *Eurypterus* (see woodcut) from the true Coal-measures at Ludlow's Pit, Radstock, Somerset.

The specimen consists of the first six body-segments only, following immediately behind the head: they measure together 53½ millimètres in length by 52 mm. in greatest breadth. The first segment, as is constantly the case, is shorter than any of the others, being only 4½ mm. deep; the 2nd is 8 mm.; the 3rd 11 mm.; the 4th, 5th, and 6th are each 10 mm. deep. The first segment is nearly straight and 42½ mm. broad; the segments gradually become more arched, and increase in breadth slightly to the 4th, which is 52 mm. broad; contracting slightly to the 6th segment, which is 47½ mm. broad. The 1st, 2nd, and 3rd segments have their lateral borders nearly straight, but the 4th, 5th, and 6th are rather more expanded and the posterior angles are produced and rather more pointed. The surface of each segment is marked by squamæ which are extremely numerous and very minute along the anterior border of each segment, but near

[1] See also Natural History of New York, Palæontology, vol. vii., by James Hall (with supplement to vol. v. part ii.), 1888, pl. xxvii. fig. 5, p. 156 (just received).

the centre and at the lateral angles these scale-markings become much larger, more acutely pointed in shape, and more irregularly distributed.

These scale-markings agree exactly with those of *Eurypterus Mansfieldi* (Hall), as represented by Prof. Hall on an enlarged scale (see plate v. fig. 6, *op. cit.* p. 38), but the margins of the segments of the Radstock specimen are hardly so pointed at their latero-posterior angles as the American species above quoted. The proportions are about equal to the largest example recorded by Prof. Hall.

In the absence of the rest of the organism, it would be premature to speak confidently; but, as it will probably prove to be a distinct British species, but near to *E. Mansfieldi* of Hall, I would propose to name it provisionally *Eurypterus Wilsoni*, after its discoverer.

NOTICES OF MEMOIRS.

Cambrian Fauna in Estland.

Ueber eine neuentdeckte untercambrische Fauna in Estland. Von F. Schmidt. Mit zwei Tafeln. (Mem. de l'Acad. des Sciences St.-Pétersbourg, vii^e série, tome 36, 1888, pp. 1–28, pls. i. ii.)

HITHERTO the Cambrian strata of the Russian Baltic provinces have proved so exceedingly poor in fossils, that it has not been possible to make a satisfactory comparison between them and the relative beds in Sweden and elsewhere. Below the *Dictyonema* shales, which are analogous to the beds of the same name in Norway and Sweden, there occurs the *Unguliten* or *Obolus* sandstones; and beneath these are beds of blue clay with subordinate layers of sandstone, which rest upon Finland granite, and have been proved by borings to reach 600 feet in thickness. The upper portions of the blue clay series in Estland were regarded by Linnarsson in 1872 as equivalent to the *Eophyton* sandstone of Sweden, and the main mass of the *Unguliten* sandstone as representing the Fucoid sandstone of the same country; but at that time no fossils were known which could substantiate these views. Lately, however, thanks to the persevering efforts of M. Mickwitz, an engineer of Reval, the fragmentary remains of a characteristic fauna have been discovered in the upper beds of the blue clay series at Reval and the neighbourhood, which fully confirm Linnarsson's opinions. The fossils which have been carefully described and figured by F. Schmidt in the present paper are *Olenellus Mickwitzi*, n. sp., *Scenella discinoides*, n.sp., *S.? tuberculata*, n.sp., *Mickwitizia* (*Obolus*?) *monilifera*, Linnars. sp., *Obolella* (?) sp., *Discina* (?) sp., *Volborthella tenuis*, n. gen. et sp., *Platysolenites antiquissimus*, Eichw. sp., *Medusites Lindstrœmi*, Linnars. sp., *Primitia* ?, *Cruziana*, and *Fræna tenella*, Linnars.

The *Olenellus Mickwitzi* comes in at a lower stage than the *O. Kjerulfi*, and is thus the oldest Trilobite known in Europe. Its occurrence at this horizon confirms the views of Linnarsson, Holm, and Brögger, that the *Olenellus* zone is distinctly older than that of *Paradoxides*.

The following table is given by the author to show the equivalents of the Cambrian strata of the Baltic provinces with those of Norway and Sweden.

Baltic.	Sweden.	Norway.	
Dictyonema-shale	*Dictyonema*-shale	*Dictyonema*-shale.	—2e
Unguliten-sand			
	Olenus-zone	*Olenus*-zone	2d 2c 2b 2a
	Paradoxides-zone	*Paradoxides*-zone	1d 1c
	Olenellus-zone.		
	Zone of *O. Kjerulfi*	Zone of *O. Kjerulfi*.	—1b
Fucoid-sand	Fucoid-sandstone.		
Zone of *Olen. Mickwitzi*	*Eophyton*-sandstone	Sparagmit-stage	1a
Blue Clay			
Lower Sandstone			

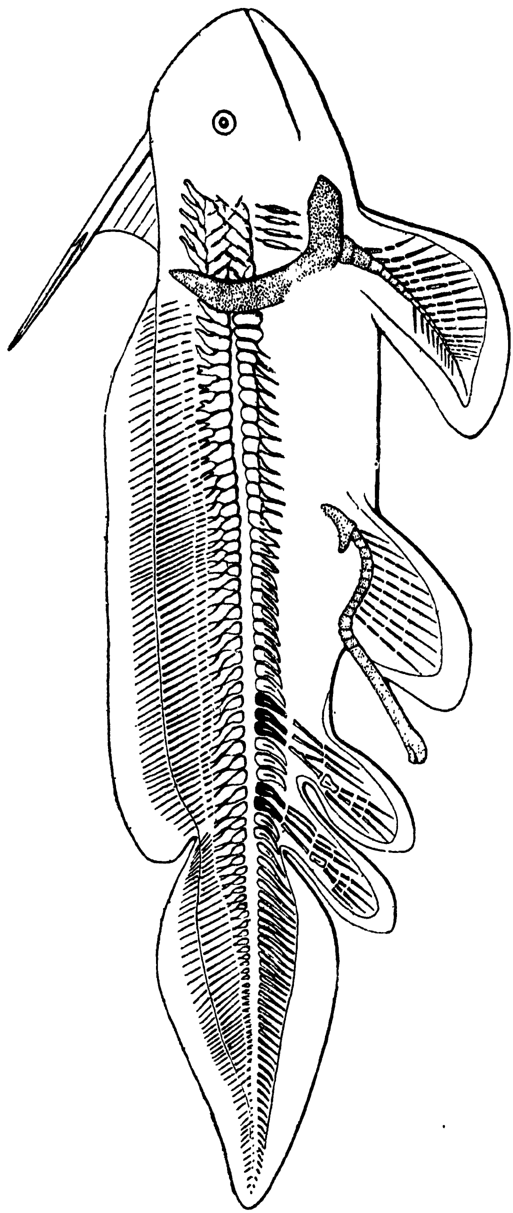
Fr. Schmidt thinks that the Baltic *Olenellus* zone is equivalent to the lower part of the St. John's group in North America, and to the lowest stages of our Harlech and Longmynd groups, in which no Trilobites have as yet been found, whilst the *Dictyonema* shales and the *Unguliten* sand may be paralleled with the Lingula Flags.

REVIEWS.

I.—M. Charles Brongniart on *Pleuracanthus*.[1]

THE precise characters of the extinct cartilaginous fishes, whose detached teeth and spines have long been known under provisional names, are now becoming gradually revealed through the progress of research; and no more interesting and important discovery has been made of late than that of the complete trunk of *Pleuracanthus*, described last April by M. Charles Brongniart, of the Paris Museum of Natural History. Through the kindness of M. Brongniart we are enabled to present the accompanying woodcut, which is a restoration of the skeleton of the fish, based upon no less than twenty-three examples of a new species (*Pleuracanthus Gaudryi*), from the Coal-measures of Commentry, Allier, France. The known individuals vary in length from 0·45 m. to 1 m., presumably owing only to their differences in age; the skeleton is always well displayed, being calcified as in Selachians, while the skin is destitute of shagreen. The body is elongate in form, and the snout obtuse. The notochord is persistent, and the bases of the neural and hæmal arches expanded; the slender neural spines bifurcate distally in the greater part of the abdominal, and the anterior half of the caudal, region. The pectoral fin, as already pointed out by Goldfuss and Anton Fritsch, is a biserial archipterygium; and each of the pelvic fins in the male is provided with a robust clasper, as in Chimæroids and Selachians. The barbed spine is placed upon the head, and forms the anterior border of a small "cephalic" fin; and a long dorsal fin commences almost

[1] "Sur un nouveau Poisson fossile du terrain houiller de Commentry (Allier)," Comptes Rendus, April 23rd, 1888.



Restoration of Pleuracanthus Gaudryi, Brongniart.

From the Coal-measures, Commentry, Allier, France.

Brongniart & Sobier del.

immediately behind, sharply separated from the upper half of the elongated diphycercal caudal, to the commencement of which it extends. But most singular and novel are the two small representatives of the anal fin, which are "placed one behind the other and have the appearance of true limbs. Narrow at their base, they enlarge mesially, and then become contracted. Their skeletal framework is almost identical. The hæmapophyses supporting them are truncated instead of ending in a point. The first two hæmapophyses bear very slender interspinous elements which are in connection each with a fin-ray. The third is larger, broad at its extremities, supporting distally a shorter broader ossicle. From this are detached, above a ray, and below two short ossicles, of which the first supports an ossicle and fin-ray, and the second two ossicles and two fin-rays. We find nothing comparable in nature, fossil or recent." It may also be added that Dr. Anton Fritsch will be able to make known interesting confirmatory—perhaps supplementary—evidence upon these points, when the Bohemian Pleuracanths are described, the writer of the present notice having been favoured with an inspection of beautiful examples in Prague.

The completed memoir on this important discovery has yet to appear, but M. Brongniart remarks, at the conclusion of the preliminary note, that, as the result of his studies, *Pleuracanthus* must be regarded as representing at least a distinct order, perhaps a sub-class, the "Pleuracanthides,"—" a group ancestral to, and connecting, the Dog-fishes, Cestracionts, Rays, Chimæras, Sturgeons, and *Ceratodus*." It is to be hoped, however, that before proposing any new term, the author will consider in more detail the conclusions of previous workers in the same direction. Prof. Cope has already placed a member of the group in a distinct order, the "Ichthyotomi," equivalent in value to the order of Selachii; and although Mr. Garman remarks, apparently with much reason, that the definition originally proposed (relating to so-called distinct traces of ossification in the chondrocranium) is very doubtfully accurate, all recent researches have tended towards as complete an isolation of the *Pleuracanthus*-like fishes as now seems inevitable. Dr. Traquair's description of the genus *Chondrenchelys*, with the appearance of a splint-like bone (? parasphenoid) upon the chondrocranium, and with complete broad vertebral rings in the caudal region, will likewise require consideration; and the same author's discovery of a uniserial archipterygial pectoral fin in *Cladodus* seems to the writer of this notice to place that much-discussed genus also in the great Pleuracanth order. The archipterygial character of the pectoral fin will certainly become one point in the broad diagnosis of the group, although, it must be admitted, a few Selachii (e.g. *Squatina*) exhibit some faint approach to that condition; and it cannot be said that the form of the teeth will count of much value, for the depressed and posteriorly expanded character of the base in the teeth of *Cladodus* is precisely paralleled in some Notidanidæ and undoubted Hybodonts, which are true Selachii. It has hitherto been too much the custom to regard every ancient fish, destitute of membrane bones and

possessing dermal structures of vascular dentine, as a member of the Selachian order; and the results of M. Brongniart's researches upon the exquisite examples of *Pleuracanthus Gaudryi* will be anxiously awaited, on account of the valuable new light they are destined to shed upon such questions.

A. Smith Woodward.

II.—Contributions to the Palæontology of Brazil; comprising Descriptions of Cretaceous Invertebrate Fossils, mainly from the Provinces of Sergipe, Pernambuco, Para, and Bahia. By Charles A. White. With Portuguese Translation by Orville A. Derby. 4to. pp. 273, and 28 Plates. (Extracted from vol. vii. of Archivos do Museo Nacional do Rio de Janeiro.)

The fossils described by Dr. White were collected some years since by the Brazilian Geological Survey under the direction of the late Professor Hartt, from low-lying rocks of sandstone, limestone, and shale, occurring in several disconnected areas bordering the Brazilian coast, from the mouth of the Amazon southwards. These rock-basins are open towards the sea, but landwards are bounded by higher ridges of crystalline, and probably Palæozoic, strata. Some of the deposits in the neighbourhood of Bahia are of freshwater origin. Both marine and freshwater beds are referred by Dr. White to a Cretaceous age, since the majority of the typical fossils from them are characteristic of this period, and some are identical with undisputed Cretaceous fossils of other regions. But with these fossils occur others of a distinct Jurassic aspect, though not specifically identical with any known Jurassic species, and, again, these are mingled with Gasteropods belonging to *Fusus*, *Murex*, *Phorus*, etc., which, if occurring alone, would have been referred to the Tertiary period. Judging by the Mollusca, the author finds this Brazilian fauna more nearly related to the Cretaceous fauna of Southern India than to any other yet known, and next after this, it approaches the fauna of the Gosau beds in the Tyrol. The freshwater Mollusca from the Bahia beds are likewise peculiar, since the species (of which 11 are described) belong to recent types.

There are 82 species of Conchifera (Lamellibranchiata) described, most of them new; the best represented families are the Ostræidæ, Limidæ, Pteriidæ, Arcidæ, Crassatellidæ, Cardiidæ, and Anatinidæ. Of Gasteropoda, 91 species have been determined, 77 of which are regarded as new; the Naticidæ, Cerithiidæ, and Fasciolariidæ are the most numerously represented families. A single new species of Polyzoa, *Lunulites pileolus*, closely resembles the *L. annulata*, Stol., from the Cretaceous of Southern India. There are 13 species of Cephalopoda, which, with the exception of a form of *Helicoceras* and one of *Nautilus*, belong to the Ammonitidæ. Fourteen species of Echinoderms are described, with one exception they are regarded as new.

All the new species, and some others as well, are carefully illustrated in the accompanying plates, and a good index is

appended. It may also be mentioned that the author gives, at the beginning of the work, a bibliographical list of publications on the invertebrate Mesozoic fossils of South America. The list only includes 24 titles, and thus indicates the slight amount of work which has hitherto been done on this group of fossils within the bounds of this continent. We note one omission; that of a short paper by Prof. E. Forbes on the Secondary fossil shells from South America, given as an appendix to Part II. of Darwin's "Geological Observations."

III.—Allgemeine Geologie, von Dr. Karl v. Fritsch, Professor an der Universität in Halle. Mit 102 Abbildungen. Bibliothek Geographischer Handbücher. Herausgegeben von Prof. Dr. Friedrich Ratzel. (8vo. pp. 500.) Stuttgart, Engelhorn, 1888.

IN Germany, not less than in England, new manuals of Geology, and new editions of old ones, appear with a frequency which indicates a considerable amount of interest, both on the part of students and of the public generally in the science of which they treat. The present volume by Prof. von Fritsch is brought out as one of a series of Geographical handbooks, and there can be no doubt of the importance of a thorough acquaintance with the facts and principles of geology to any one who aims at a real knowledge of geography. This book seems to be well adapted for its purpose; though necessarily it covers the same ground as other manuals of the science, the subject is treated from an independent point of view, and the author may justly claim that it is not a mere compilation, but has been based on his own study and observation of the facts. The following is the arrangement adopted in the work:—I. Geophysiography; II. Geotectonic or Stratigraphy; III. Geochemie or Chemical Geology, including Petrography and Lithology; IV. Geomechanic or Physical Geology; and V. Geogenie or Historical Geology. The facts and deductions relating to each of these divisions are stated very clearly and concisely, and the work may be commended, not merely to beginners, but to students of Geology generally.

G. J. H.

IV.—Salt-Range Fossils. By William Waagen, Ph.D., F.G.S. I. Productus-Limestone Fossils: 6. Cœlenterata, Memoirs of the Geological Survey of India, 1886, pp. 835–924, plates xcvii.–cxvi.

IN this elaborate memoir the Corals of the Carboniferous Limestone of the Salt-Range of the Punjab are described in detail, and illustrated on a scale which might give rise to the envy of non-official palæontologists, who have to be content with figures of much humbler proportions. These Corals are, for the most part, of the same general characters as those of the Devonian and Carboniferous strata of this country and North America. They belong to the genera *Aræpora, Pachypora, Michelinia, Monotrypa, Orbipora, Geinitzella, Stenopora, Lonsdaleia, Amplexus, Hexagonella, Dybow-*

skiella, and *Fistulipora*. Of these, *Geinitzella*, *Hexagonella*, and *Dybowskiella* are proposed as new, but their characters are so similar to those of *Stenopora*, *Evactinopora*, and *Fistulipora* respectively, that the author might well have spared the introduction of the new names. A very important feature in the description of these Corals is the way in which their minute structures have been investigated by means of microscopic sections, of which several hundreds were prepared by Mr. Wentzel, the colleague of Prof. Waagen in the authorship of this memoir. A comparison of the beautiful figures given of these sections, with those of nearly allied forms which have appeared in the papers of Prof. Nicholson and Mr. Foord, fully shows the value and absolute necessity of basing the determination of these and other Corals on their minute structural characters. In the interpretation of some of these minute structures, the authors of this memoir differ considerably from Prof. Nicholson; but we are inclined to think that, as regards the nature of the wall in the axial corallites, the view of Prof. Nicholson, that it is really double, better accords with the facts, than the explanation that it is single, and that fracture really takes place between it and the subsequently deposited layers of stereoplasm. Further, the evidence seems insufficient to establish the statement that the spinous structures in many of the Monticuliporidæ, the Acanthopores of Nicholson, are merely the young stages of the ordinary corallites. Other points, on which somewhat dogmatic opinions are given, are likewise open to criticism; but we must content ourselves with an expression of satisfaction that these organisms have been so thoroughly and carefully investigated and described; so that this memoir is a refreshing contrast to some of the earlier publications of the Indian Survey, in which the superficial features of the Corals merely have been noticed. A tabular statement of the species described in the memoir would have increased its value and convenience for reference.

G. J. H.

CORRESPONDENCE.

THE ATMOSPHERE OF THE CARBONIFEROUS PERIOD.

Sir,—May I be permitted one word on a question which has been raised as to the greater prevalence of carbonic acid in the atmosphere of this earth in the Carboniferous Period than at later periods, if only to suggest that Prof. Prestwich and his critic seem to be arguing at cross-purposes? There is no reason why both statements should not be true. The real question would then be, as to what would constitute "an excess of carbonic acid." There is some confusion of thought as regards such two essentially different physiological functions of plant-life and growth as *respiration* and *assimilation of carbon*. This is hardly excusable when we need go no farther than the most trustworthy elementary books (such as those in the London series), to be informed of the essential difference of these two processes, and of necessity of free oxygen for the activity of protoplasm in the plant and animal alike. On general grounds therefore

we should expect that a moderate increase (beyond the mere four parts in 10,000 of our present atmosphere) of the food-stuff (carbonic acid) of plants would be favourable to more rapid production of vegetable tissue; and on the same grounds we should equally expect that such an increase of the same gas, as to practically asphyxiate plants, would be fatal to them. But between the two limits there is ample room for Prof. Prestwich's hypothesis, which is probably well founded.

Why not experiment on the question? It is easy enough.

Sachs (*Lehrb. d. Botanik*, p. 692) states that "experiments on plants (Vegetationsversuche) show that growth and the changes of material necessarily associated therewith only take place in the tissues (of plants) so long as free oxygen has access to them: in the absence of free oxygen (in einer saüerstofffreien Atmosphäre) no growth takes place; and if plants remain a longer time in such an atmosphere they die."

If, however, the percentage of carbonic acid in the present atmosphere were multiplied, say 100-fold, its volume would still be less than one-fifth that of the free oxygen present. This we should scarcely expect to reach the asphyxiation-proportion for plants. The above quotation is from the Leipzig edition (1874) of Sachs' great work. It is probable that in the recent new edition much fuller information is to be found.

WELLINGTON COLLEGE, BERKS. A. IRVING.
4*th May*, 1888.

OBITUARY

PROF. HENRY CARVILL LEWIS, M.A., F.G.S.

BORN NOVEMBER 16TH, 1853; DIED JULY 21ST, 1888.

AMONGST the many and varied ties which serve to bind America and England together in friendly union, there are probably none more sincere and reciprocal than those which subsist between the scientific men of the two countries.

As Englishmen we take the warmest interest in the grand development of that wonderful country "on the other side," and the hearty reception given to our American cousins here is returned with equal or even greater warmth by them, whenever we visit the New World.

It is doubtless owing to their greater energy and enterprise that Americans are by far the more frequent visitors to our shores than are we to theirs. This is no doubt largely due to the historical attractions which an old country always offers to a new one, and also the desire to compare our scientific work and institutions with their own.

No one amongst the many young scientific Americans of note has more earnestly cultivated English and European methods of research, or has worked with greater enthusiasm to carry his geological investigations from North America into Britain, than the subject of this brief memoir, Professor Carvill Lewis. H. C. Lewis was

born in Philadelphia, November 16th, 1853, being the son of Mr. F. Mortimer Lewis and Emma Hulme (Carvill) Lewis, of that city. At the age of 20 he graduated B.A. with first honours in Classics at the University of Pennsylvania, taking his M.A. degree in 1876. He took a post-graduate course of three years in Natural Science, and between 1879 and 1884 he served as a volunteer on the staff of the Geological Survey of Pennsylvania; investigating at first the surface-geology of Southern Pennsylvania, and afterwards the Glacial phenomena of the Northern part of that State. Here he succesfully traced the great terminal moraine of the North American Ice-sheet from New Jersey to the frontier of Ohio. During this period he contributed a number of papers to the Academy of Natural Sciences of Philadelphia upon the mineralogy and geology of Pennsylvania.

In 1880 he was elected Professor of Mineralogy in the Academy of Natural Sciences, Philadelphia, and in 1883 he was appointed Professor of Geology in Haverford College, Pennsylvania, U.S.

In 1882 Prof. Carvill Lewis married Miss Julia C. Foulke, daughter of the late Mr. W. Parker Foulke of Philadelphia, a man of varied attainments and wide scientific interests.

Between 1885 and 1888 he was engaged in studies and original investigations in Europe; the winters being spent in Heidelberg, where he worked at microscopic petrology and crystallography, under the guidance of Prof. Rosenbusch, and the summers in the field tracing out the difficult and complex problems connected with the Glacial Epoch in Great Britain and on the Continent.

Here he had completed a map of the ancient glaciers and ice-sheets of England, Wales and Ireland, which was exhibited and discussed at the British Association, Birmingham, 1886; Manchester, 1887; and elsewhere.

He had also commenced similar studies in Switzerland and North Germany. These, however, were interrupted by a visit to America, where he contracted typhoid fever, which developed in a sudden and alarming manner immediately on his return to England, and terminated fatally on July 21st, at Manchester.

Prof. Carvill Lewis was a Fellow of the Geological Society of London; of the Geological Society of Germany; a Member of the American Philosophical Society; of the Academy of Natural Sciences of Philadelphia; the Franklin Institute; the American Association; a Corresponding Member of the British Association; and a Member of the Geological Society of Liverpool.

It is always sad to see a bright young life suddenly cut short in early manhood, but it is more especially so when, as in the case of Prof. Carvill Lewis, such good work had been already done, and we had abundant promise of a splendid future scientific career.

Over and above all this Prof. Lewis had such a happy, bright and genial manner, that he readily won for himself the warm regard of a very wide circle of friends, whilst among men of science he seemed to give sure promise of a long life of solid and valuable work. His loss will be keenly felt both in America and Europe, not only amongst geologists, but men of science generally.

The following are amongst his more important papers :—

"On Philadelphite, a new Mineral Species." (Proc. Acad. Nat. Sci. Philadelphia, 1879.)
"The Optical Characters of some Micas." (Proc. Acad. Nat. Sci. Philadelphia, 1880, pp. 244-251.)
"Siderophyllite, a new Mineral." (Proc. Acad. Nat. Sci. Philadelphia, 1880, pp. 254-255.)
"The Surface Geology of Philadelphia and its vicinity." (Journ. Franklin Institute, 1883.) (Proc. Acad. Nat. Sci. Philadelphia, 1880, pp. 258-272.)
"The Trenton Gravel and its relation to the Antiquity of Man." (Proc. Acad. Nat. Sci. Philadelphia, 1880, pp. 296-309.)
"The Iron-ores and Lignites of Montgomery Co. Valley." (Proc. Acad. Nat. Sci. Philadelphia, 1880, pp. 282-291.)
"A New Fucoidal Plant from the Trias." (Proc. Acad. Nat. Sci. Philadelphia, 1880, pp. 293-294.)
"Some Enclosures in Muscovite." (Proc. Acad. Nat. Sci. Philadelphia, 1882, pp. 311-315.)
"An American Locality for Helvite." (Proc. Acad. Nat. Sci. Philadelphia, 1882, pp. 100-102.)
"Pseudomorphs of Serpentine after Dolomite." (Proc. Acad. Nat. Sci. Philadelphia, 1882, pp. 36-38.)
"The Great Terminal Moraine across Pennsylvania." (Proc. Amer. Assoc. Adv. Sci. Montreal, 1882.—*Science*, 1883, vol. ii. pp. 163-167.)
"On a Supposed Human Implement from the Gravel at Philadelphia." (Proc. Acad. Nat. Sci. Philadelphia, 1883, pp. 40-43.)
"Phosphorescent Variety of Limestone." (Proc. Acad. Nat. Sci. Philadelpia, 1884, pp. pp. 10-12.)
"Report on the Great Terminal Moraine across South-Eastern Pennsylvania and Western New York, 1884, pp. 299, maps, sections. and photograhs.
"On Supposed Glaciation in Pennsylvania South of the Terminal Moraine." (Amer. Journ. Sci. 1884, vol. xxxiii. pp. 276-288.)
"Erythrite, Genthite and Cuprite from near Philadelphia." (Proc. Acad. Nat. Sci. Philadelphia, 1885, pp. 120-122.)
"Marginal Kames." (Proc. Acad. Nat. Sci. Philadelphia, 1885, pp. 157-173.)
"A Great Trap Dyke across South-Eastern Pennsylvania." (Proc. Am. Phil. Soc. 1885, pp. 438-456.)
"Comparative Studies upon the Glaciation of North America, Great Britain, and Ireland." (Geol. Mag. 1887, Ser. III. Vol. IV. pp. 28-32.) British Assoc. Reports, Birmingham, 1886.
"On a Diamantiferous Peridotite" and "The Genesis of the Diamond." (Brit. Assoc. Rep. Birmingham, 1886.) (Geol. Mag. Ser. III. Vol. IV. 1887, pp. 22-24.) (*Science*, vol. viii. 1886, pp. 345-347.)
"The Terminal Moraines of the Great Glaciers of England." (British Assoc. Reports, Manchester, 1887.) (Amer. Journal Science, 1887, ser. iii. vol. 34, p. 402.)
"On some extra-Morainic Lakes in England, North America, and elsewhere during the Period of Maximum Glaciation, and on extra-Morainic Boulder-clay." (British Assoc. Reports, Manchester, 1887.) (Geol. Mag. 1887, p. 515.)
"On the Matrix of the Diamond." (Brit. Assoc. Reports, Manchester, 1887.) (Geol. Mag. 1888, p. 129.)
"The Terminal Moraine of the Irish Sea Glacier near Manchester." (Brit. Assoc. Reports, Manchester, 1887.)

THE TERMINAL MORAINES OF THE GREAT GLACIERS OF ENGLAND.

NOTE.—Mrs. Lewis desires to state that, after the meeting of the British Association at Manchester last year, Prof. Carvill Lewis set out in company with herself and Dr. H. W. Crosskey, of Birmingham, to visit and examine Frankley Hill, in Worcestershire, the only alleged deposit of glacial "Till" south of the great Moraine line which he had not seen prior to the Manchester meeting. Here an excavation was made, under Prof. Lewis's superintendence, through the gravel to a depth of from eight to ten feet; thence the party traced the few detached Arenig boulders to the frontier of Wales. Prof. Carvill Lewis then said that for the first time in all his experience, both in the old and new world, he had found unmistakeable evidence of a glacier, between which and the Glacial Epoch there was as vast an interval of time as between that and the present day. It was the intention of the late Prof. Lewis to make a thorough re-examination of all England, lest a similar deposit elsewhere might have escaped his notice; but now that his labours have been so suddenly brought to a close, Mrs. Lewis thinks this statement should be put on record.—H.W.

AMOS H. WORTHEN.

PALÆONTOLOGIST AND GEOLOGIST.

BORN OCTOBER 31ST, 1812; DIED MAY 6TH, 1888.

AMOS H. WORTHEN, a son of the late Thomas Worthen, was born at Bradford, Orange County, Vermont. He commenced life as a Schoolmaster in Harrison County, Kentucky, but in June, 1836, he removed to Warsaw, Illinois, where he spent the remainder of his life. While engaged in business, he became interested in the science of Geology, and made a large collection of fossils, and also of those remarkable geodes of the Keokuk limestone in that region.

On the institution of the Geological Survey of Illinois in 1851, under Prof. J. G. Norwood, he was appointed his Assistant, which post he filled for four years. From 1855 to 1857 he was Assistant to Professors James Hall and J. D. Whitney on the Geological Survey of Iowa, and the volume published in 1858 owes much of its value and interest to the labours of Mr. Worthen. The many beautiful plates of this large volume are from drawings by Mr. F. B. Meek, who was afterwards associated with Mr. Worthen in the palæontology of his own Reports.

In March, 1858, Mr. Worthen was appointed by the State to the charge of the Geological Survey of Illinois, which position he occupied till 1872, when he became Curator of the Illinois State Museum.

The seven completed volumes of the Geology and Palæontology of Illinois form the best and most lasting monument to his memory. Mr. Worthen left an eighth volume in the press. Besides these voluminous reports, he issued a large coloured geological map of Illinois, and three volumes on the Economical Geology of the State. He was also the means of gathering for the State Museum one of the largest and best collections of fossils in the country.

In the early part of the Survey Mr. Worthen encountered and overcame great opposition. His modesty and earnestness, high character and quiet dignity, gave him great influence, and the many difficulties disappeared before him. Although nearly 75 years of age at his death, he had not given up work; the preparation of the text and plates illustrating the Silurian Invertebrate fossils of Illinois, for the eighth volume, was occupying him, when a sudden attack of pneumonia brought all to an end.—*Silliman's American Journal*, August, 1888.

WILLIAM HELLIER BAILY, F.L.S., F.G.S., M.R.I.A.

PALÆONTOLOGIST AND GEOLOGIST.

BORN JULY 7, 1819; DIED AUGUST 6, 1888.

WE regret to announce the death, at Rathmines, near Dublin, of Mr. W. H. Baily, who, after a lingering illness, passed away on August 6, at the age of 69. The greater portion of his life was

devoted to Palæontology, and most of the fossils which he described, and those which illustrated his works, were drawn on wood or stone by his skilful hand.

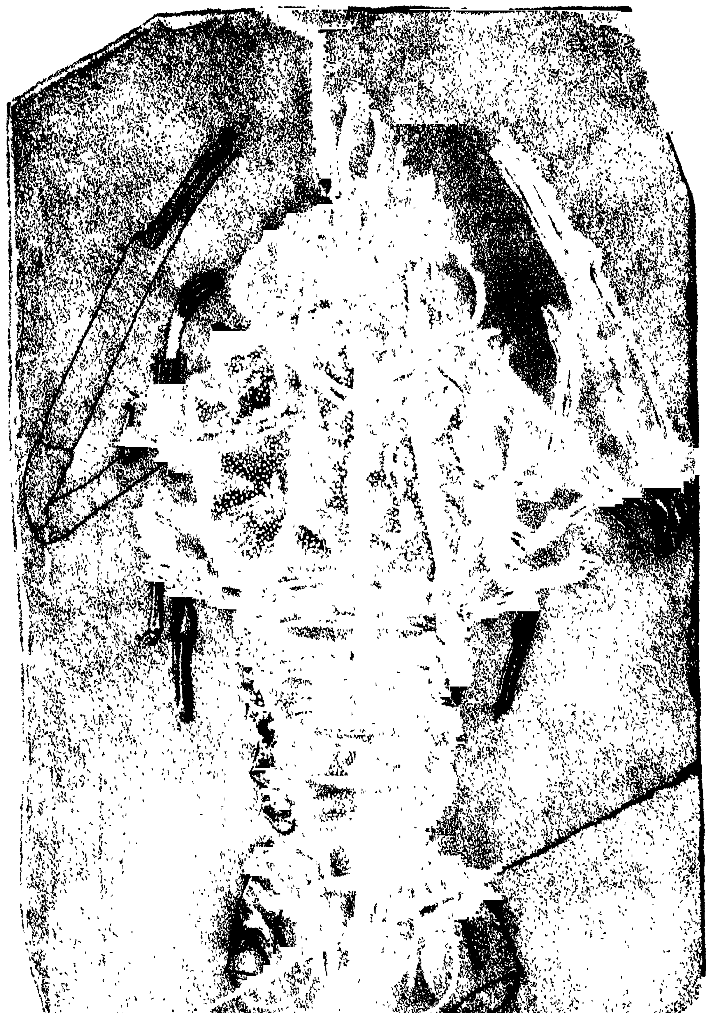
Mr. Baily was born at Bristol on July 7th, 1819, and he inherited artistic talent, for both his grandfather and father, as well as his uncle, Edward Hodges Baily, R.A., were remarkable for their carving and sculpturing. He began his scientific career in 1837 as Assistant Curator in the Bristol Museum, resigning this post in 1844, when he was attached to the Geological Survey of Great Britain as Draughtsman. In the following year he was appointed to the staff as Assistant Geologist under Sir Henry De la Beche. His duties, however, were confined to the Museum work, and in 1854 he was styled Assistant Naturalist, serving for a time directly under Edward Forbes, and afterwards under Professor Huxley. In 1857 he was transferred to the Irish branch of the Geological Survey, as Acting Palæontologist, and he retained this post till the close of his life. In 1868 he received the additional appointment of Demonstrator in Palæontology to the Royal College of Science for Ireland.

Mr. Baily was the author of many papers on palæontological and kindred subjects, and his labours will be best shown by the list of his works, which amount to 43 in number. His most important private work was that published in parts from 1867 to 1875, being Figures of Characteristic British Fossils: with descriptive remarks. Unfortunately, the work did not sufficiently recompense the author from a pecuniary point of view, and after the first volume was published, completing the Palæozoic portion, it was abandoned. In 1867 he received the proceeds of the Wollaston Donation-fund, awarded by the Geological Society of London, in aid of this work. His official labours comprised Palæontological Notes in the Explanatory Memoirs to the Maps of the Geological Survey of Ireland, and the list of these alone would be a lengthy one.

Mr. Baily, like the late Prof. Morris, and Mr. J. W. Salter, with whom he was a contemporary and a fellow-worker, belonged to that small body of Geologists and Palæontologists, now, alas! nearly all passed away, who possessed an extensive general knowledge both of rocks and fossils, and also the invaluable ability *to draw*, as well as to describe, what they saw and studied, whether in the field or in the cabinet. These men can never be replaced by our modern student-specialists.

Personally Mr. Baily was of a genial disposition and his loss will long be felt by his friends and colleagues.

Errata.—Please make the following corrections:—Geol. Mag. March No. p. 123, in footnote, line 2, for "Memoir" read "*Meunier.*" In May No. p. 240, line 33 from top of page, for *the work which* Mr. Lee *has actually done*—read "the work which *we see* actually done."—In August Number, p. 382, line 3 from bottom, for *lavas* read *laws*.—Edit. Geol. Mag.



G. M. Woodward, del. et lith. West, Newman & Co imp.

Eryon antiquus, *Broderip, sp.*
L. Lias. Lyme Regis.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. V.

No. X.—OCTOBER, 1888.

ORIGINAL ARTICLES.

I.—On *Eryon antiquus*, Broderip, sp., from the Lower Lias, Lyme-Regis, Dorset.

By Henry Woodward, LL.D., F.R.S., V.P.G.S.,
of the British Museum (Natural History).

(PLATE XII.)

So far back as the year 1820, Schlotheim described in his Petrefactenkunde, vol. i. p. 37, certain Oolitic Crustacea from Solenhofen, which he called *Macrourites;* but forms belonging to more than one genus were included by him under this name.

We are indebted to M. Desmarest, in 1822, for the earliest description of the genus *Eryon* from the Lithographic Stone of Solenhofen.[1]

A form of *Eryon* was described in 1835, from the Lias of Lyme-Regis, by Mr. W. J. Broderip,[2] F.R.S., under the name of *Coleia antiqua.* In the same year Prof. von Meyer described an *Eryon* from the Upper Lias of Rabenstein, Bavaria, under the name of *E. Hartmanni.*[3]

In 1849 Prof. McCoy[4] described, but did not figure, an *Eryon* from the Lias of Leicestershire under the name of *E. Barrovensis.*

Ten species of *Eryon* have been described by Schlotheim,[5] Münster,[6] Etallon,[7] Germar,[8] Fraas[9] and Oppel,[10] mostly from the Lithographic Stone of Solenhofen. *Eryon*[11] *Escheri* was described by Oppel from the Lower Lias of Schambelen, Switzerland, and *Eryon Edwardsi* by M. Morière,[12] from the U. Lias of Calvados, Normandy.

In 1866 I described and figured several British Liassic species of *Eryon,*[13] viz —*E. Barrovensis, E. Wilmcotensis, E. Brodiei, E. crassichelis,* and *E. Moorei;* also *E. Oppeli* from Solenhofen.

In 1881 I added another British species of *Eryon, E. Stoddarti,*[14] from the Stonesfield Slate, and *E. Neocomiensis,*[15] from the Lower Cretaceous of Silesia.

[1] Nat. Hist. Foss. Crust. 1822, p. 128.
[2] Trans. Geol. Soc. 1835, 2nd ser. vol. v. p. 172, pl. 12, figs. 1 and 2.
[3] Bronn, Jahrb. 1836, p. 329.
[4] Ann. Mag. Nat. Hist. 1849, p. 172.
[5] Petrefactenkunde, 1822, p. 35, tab. 3, fig. 2.
[6] Beitrage zur Petrefk. 1839, vol. ii. p. 2.
[7] Etallon in Bullet. Soc. Geol. de Fr. 1858, xvi. p. 169, t. 4, figs. 1–3.
[8] Germar in Keferstein. Deutschl. 1827, iv. p. 99.
[9] Württemb. naturw. Jahresh. 1855, xi. Jahrg. p. 94.
[10] Pal. Mittheil. 1862, p. 8, tabs. 1–3.
[11] Pal. Mittheil. 1862, p. x. t. 1, fig. 1.
[12] Bull. Soc. Linn. de Normandie, 1864, tome viii. p. 89, pl. vi.
[13] Quart. Journ. Geol. Soc. 1866, vol. xxiii. p. 493, pl. xxiv. and xxv.
[14] Geol. Mag. 1881, p. 529, Pl. XIV. Fig. 2.
[15] Geol. Mag. 1881, p. 530, Pl. XIV. Fig. 1.

In 1883 M. Morière described a second species of *Eryon* under the name of *E. calvadosi*[1] from the Upper Lias of Calvados.

In 1884 Mr. C. Spence-Bate, F.R.S., figured and described a species of *Eryon* from the Lias of Lyme-Regis, Dorset, under the name of *Archæastacus Willemœsii.*[2] I ventured to point out, in a footnote to his paper (see GEOL. MAG. 1884, p. 310) that the specimen so described was almost certainly identical with *Eryon crassichelis*, H. Woodw., 1866 (see Quart. Journ. Geol. Soc. 1866, vol. xxii. p. 497, pl. xxv. fig. 2).

In August, 1888, the two fine volumes xxiv. (text and plates) of the "Challenger" Report on the Crustacea-Macroura by Mr. C. Spence-Bate, F.R.S., were received by me. In this magnificent Monograph the author discusses, under "Morphology," p. xv, and again under the *Eryonidæ* (pp. 100–120), both the past and present representatives of this family, and he gives a conjectural restoration of his "*Archæastacus Willemœsii*" (? = *Eryon crassichelis*, H. Woodw.), which, however, differs considerably from the actual specimen, as may be seen by a comparison of the carefully-drawn Plate X. GEOL. 1884, MAG. with the "Challenger" woodcut on p. 117.

The most important points to be noticed in the *new figure* are, the omission of the articulation (*diæresis*) in the outer lamella (exopodite) of the sixth segment of the abdomen (forming the "*rhipidura*," or "tail-fan" of Spence-Bate); the exaggerated size of the *scaphocerite* or antennal scale—certainly more than twice the natural size; and the incorrect representation of the basal joints of the antenna. This latter is due to Mr. Spence-Bate having mistaken the three terminal joints of the exopodite of the maxillipede (preserved in the fossil on the right side) for the basal joints of the antenna. The antennules in the original specimen do not bend outwards over the antenna as here represented, the former with their short bifid multiarticulate flagella being directed forwards, and the latter with its single flagellum, and short ovoid basal scale, being curved *outwards*. Lastly, it is quite certain that the latero-anterior margin of the carapace is not perfect in the fossil, and does not justify the representation given of a smooth rounded margin; the evidence on the surface of the carapace of a cervical furrow bifurcating on each side justifies the assumption that the margin would be intersected by two indentations one at the end of each branch of the cervical furrow, and marked by a more or less pointed lobe enclosed between these two indentations, a form of carapace most characteristic of the genus *Eryon*.

In 1835 Mr. W. J. Broderip described in the Transactions of the Geological Society of London (2nd series, vol. v. pl. 12, figs. 1, 2, p. 172), a new Macrourous Decapod Crustacean from the Lias of Lyme-Regis, which he named *Coleia antiqua*. The larger fossil figured by Broderip is very imperfect, but the smaller is more complete; both examples display sufficient evidence in the carapace and appendages to have justified Dr. Oppel in his conclusion that they belonged to the genus *Eryon* (Pal. Mittheil. 1862, p. 11).

[1] Bull. Soc. Linn. de Normandie, 1883, sér. 3, tome vii. pp. 1–10, pl. i.–iii.
[2] GEOL. MAG. 1884, Dec. III. Vol. I. Pl. X. p. 307.

Another example of *Eryon* (*Coleia*) *antiquus* from the same locality and formation having been obtained for the British Museum, it seems to me to deserve to be recorded and figured (see Plate XII.), as this is evidently a rather rare species in our Lias.

Description.—The whole specimen measures 11½ centimètres in length; the cephalothorax is 5¼ centim. long and 5 c. at its broadest part just behind the cervical furrow, and 4 c. wide at its posterior border. The hinder border is nearly straight, being but slightly arched, or concave, forwards. At a distance of 3 c. from the posterior border there is a well-developed rather incurved tooth or spine marking the posterior margin of the first lateral indentation of the carapace 5 mm. deep. At 3¾ centimètres from the posterior border the 2nd lateral roundly-incurved tooth arises. Here the carapace becomes narrower, being only 4¼ c. in breadth. This 2nd rounded serration also marks the second lateral indentation 6 mm. deep; this may be called the cervical notch, as it unites with the cervical furrow, which here crosses the carapace in a clearly-marked obtusely V-shaped line. In front of this cervical notch, the carapace again expands, forming a rounded lobe on each side, ending in a third antero-lateral tooth; here the carapace has contracted to a breadth of 2½ centimètres; this tooth forms the outer border of the orbital fossa 6 mm. broad; the inner margin of which is formed by a spine 6 mm. long, which rises up on either side of the deep frontal fossa, 12 mm. across, and broadly U-shaped, which occupies in the carapace of *Eryon* that space usually filled by the rostrum in other Macroura, but which is not developed in the *Eryonidæ*.

In this frontal fossa the antennules are seen with their three basal joints and their bifid flagella, the outer flagellum being 11 mm. long and the inner 16 mm. Just inside the antennules are preserved the four distal joints of the two palpi (or endopodites) of the 3rd or external pair of maxillipedes. Only portions of the flagella of the outer antenna with their basal joints are preserved. Near the base of these, the flattened remains of the ophthalmopods are seen lying in the orbital fossa on each side.

The great length of the first pair of chelate thoracic legs is very characteristic of *E. antiquus*, and strikingly in contrast with all the other species of *Eryon*, save *E. bilobatus*, *E. longipes*, and *E. Redenbacheri*, from Solenhofen (see Oppel's Pal. Mittheil. pp. 16–18, tab. 3, figs. 2, 3, 6). They are, in our fossil, 11½ centimètres long. The 2nd pair, also chelate, are much smaller, being 4¼ c. long. The 3rd and 4th pairs were also chelate and the 5th pair simple.

The abdomen measures 6¼ centimètres in length, including the telson, which is 2 c. long. Its widest part is at the 2nd segment, which is 3½ c. wide, the 6th being 2½ c.: the breadth of the swimmerets of the tail is 6¼ c. The telson is 14 mm. broad. The sternal arches of the segments are narrow near the centre, with wide intersternal membranes; but they become broader near their rounded epimeral borders.

Each somite or segment bears upon the centre of its tergal arch a strong tubercle; the whole surface of the segments being coarsely

granular. The telson has three longitudinal ridges upon it. The tail-lobes or swimmerets are broadly rounded, and the outer plate has a diæresis across its lower extremity. The surface of the carapace is strongly granulated, the centre or dorsal line being marked by a strong line of tubercles which die out forwards, just beyond the cervical furrow. In addition to the dorsal ridge two lateral lines of smaller tubercles further subdivide the carapace longitudinally, marking off the branchial region on either side. The lateral margins of the carapace are also marked by minute spines and tubercles.

Referring again to Mr. C. Spence-Bate's remarks on the genus *Eryon*, including as at present constituted many species from the Solenhofen Limestone in which the diæresis, or suture dividing the outer lobe of the caudal fin, is absent, and many from the English Lias, etc., in which it is distinctly present, Mr. Spence-Bate contends —and he is probably justified in his contention—that the absence or presence of this diæresis is of generic, if not of family, value; and further that there are many other distinctive characters amongst the various species of *Eryon* which are of sufficient importance to constitute generic differences. He has separated from the genus *Eryon*, under the name of *Archæastacus Willemœsii*, a Liassic form from Lyme-Regis (see Geol. Mag. 1884, Pl. X. and p. 307; see also "Challenger" volume, 1888, p. 117), which he believed had *no diæresis*, but which has in fact a well-marked one. Apart from this, it has no salient character which would entitle it to be treated as generically distinct from other Liassic forms of *Eryon*. But if the presence or absence of a *diæresis* in the outer lobe of the tail-fan be deemed of generic value, then all those forms *in which this suture is absent*, must be retained in the genus *Eryon*,[1] whilst those in which a *diæresis* is present, must form a new genus.

Unfortunately the name *Archæastacus*, proposed by Mr. Spence-Bate, cannot stand, as it was given in error to a form which its author believed to be destitute of a *diæresis*, whereas it possesses one. But if the Liassic species must be separated for this reason from the genus *Eryon*, then Broderip's genus *Coleia* (1835) should be revived, as having the priority, by more than fifty years, over the generic name proposed by Spence-Bate.

Mr. Spence-Bate quotes the writer as to the rarity with which the eyes are found preserved in fossil forms of the genus *Eryon*. He writes: "The eye is but rarely if ever preserved, and Woodward says, '*has never been positively determined*,' and the peduncle on which it is supposed to stand frequently appears as if it were biarticulated; but I have never seen a specimen, or the figure of one, in which the perfectly-formed eye has been found so as clearly to determine its form and character."

I cannot find the above italicized quotation, but I do say (Quart. Journ. Geol. Soc. 1866, p. 496): "The eyes, but rarely preserved, are placed"—in *Eryon Barrovensis*—"near the base of the scale of the outer antennæ." Again under *E. Brodiei* (op. cit. p. 498): "In this specimen, one eye is preserved *in situ*."

[1] The genus *Eryon* was founded by Desmarest on specimens from Solenhofen which have *no diæresis* in the tail-fan.

In Oppel's "Palæontologische Mittheilungen" (1862) he figures several *Eryon* from Solenhofen; e.g. *E. arctiformis*, Schlot. sp. (*op. cit.* Tab. 3, fig. 1), and he marks (*o, o*) "Augenstiele," and on Tab. 2, figs. 1, 2, 3 (*o, o*) "Einschnitte im Cephalothorax für die Augen." In the description of the figure given by him ("Challenger" Report, p. xv) of *Eryon calvadosii* (after M. Morière) "the orbits," says Spence-Bate, "for the reception of the organs of vision are well preserved." Bearing in mind the usually delicate nature of these organs, it is not surprising to find them more often represented by their orbital vacuities than by the eyes themselves.[1]

We cannot follow Mr. Spence-Bate in his conclusions that we find "in the same geological epoch some specimens of *Eryon* that are *blind*, and others with large and probably well-developed organs of vision" (*op. cit.* p. xvi). Such a deduction, based upon our present imperfect knowledge of fossil forms, would be as erroneous as to conclude that the Venus of Milo was originally sculptured without arms because they are now reduced to stumps.

During the cruise of the "Challenger," two genera of deep-sea Crustaceans allied to *Eryon* were obtained by Dr. v. Willemoes-Suhm, the late talented Naturalist to the Expedition, whose lamented death occurred before the completion of the voyage.

By the kindness of Dr. John Murray, F.R.S.E., the Director of the "Challenger" publications, I am permitted to reproduce figures of these very remarkable living representatives of this well-marked and ancient family of Jurassic Crustaceans.

The first of these, *Polycheles crucifera*, was dredged off Sombrero Island, West Indies, in a depth of 480 fathoms (*op. cit.* p. 127). Another specimen is mentioned (at p. 100) as having been dredged in the middle of the North Atlantic at a depth of 1900 fathoms, or rather more than two miles from the surface! (see Woodcut, Fig. 1).

"The eye is lodged in a narrow cleft of the dorsal surface of the carapace, and projects beneath the antero-lateral angle of the carapace in the form of an obtuse point" (*op. cit.* p. 127). "The animal," says Mr. Spence-Bate, "can have had only a very limited range of vision outwardly, by the aid of one lens above, and another below and a little in advance, and even this, from the apparent density of the cornea, must have been of a very imperfect character" (*op. cit.* p. 128).

Another species, *Polycheles Helleri*, Bate, dredged to the north of New Zealand, in a depth of 520 fathoms, and again north of New Guinea, at a depth of 1070 fathoms, appears to have had equally imperfect vision (*op. cit.* p. 139).

The second form, *Pentacheles euthrix* (Woodcut, Fig. 2), was dredged off the Kermadec Islands in depths of 520 and 630 fathoms; and again off Matuku, in 315 fathoms.

"The ophthalmopod is lodged in a notch in the carapace that is

[1] In the recent forms described by Mr. Spence-Bate the eye was found to be almost entirely concealed beneath the antero-lateral angle of the carapace, see woodcut of ophthalmopod of *Pentacheles gracilis* ("Challenger" Report, or CRUSTACEA-MACROURA, vol. xxiv. p. 114, fig. 28; also vol. xxiv. plate xvii. figs. C *a*, C ii. *a*, C iii. *a*.)

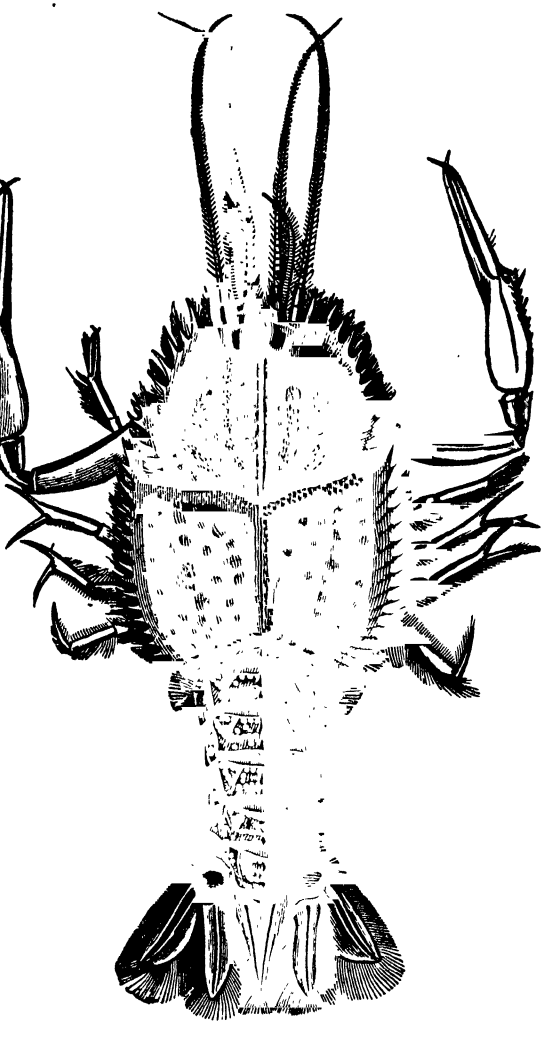


Fig. 1. *Polycheles crucifera.*

From a drawing by Dr. v. Willemoes-Suhm.

(Reproduced by permission from the "Challenger" Report on Crustacea-Macrura, vol. xxiv. p. 131, fig. 31.)

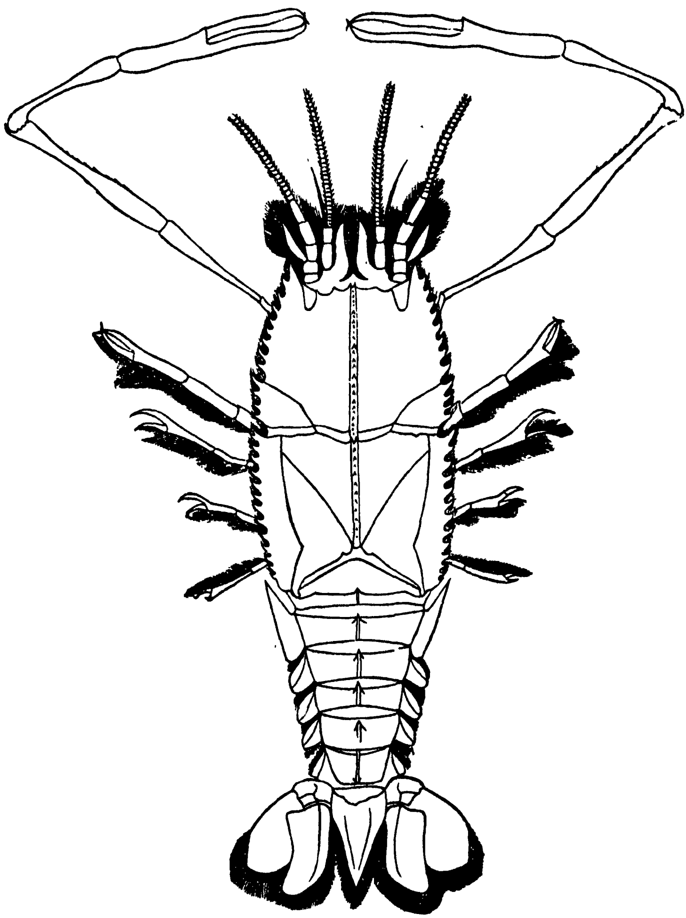


FIG. 2.—*Pentacheles euthrix.*

From a drawing by Dr. v. WILLEMOES-SUHM.

(Reproduced by permission from the "Challenger" Report on Crustacea-Macrura, vol. xxiv. p. 150, fig. 33.)

much broader at the anterior margin, and narrower posteriorly; it carries a small, pointed cusp on the anterior surface, and passes outwards beneath the projecting angle of the carapace, and terminates in two small nodules, one on the outer, and the other on the lower side" (*op. cit.* p. 151).

Three other species are recorded by Mr. Spence-Bate, viz.—*P. obscura*, north of New Guinea, depth 1070 fathoms; *P. lævis*, between Samboagan and New Guinea, 500 fathoms; *P. gracilis*, off Kandavu Island, in 610 fathoms.

It can hardly be doubted that in these remarkable deep-sea forms we have the last survivors of a once numerous family of Crustacea-Macrura with broad and flattened carapaces, destitute of any rostrum, serrated more or less along their lateral margins, and generally marked by a strong cervical furrow which is usually branched laterally.

That these modern forms should either be quite blind, or have but imperfect vision, does not seem extraordinary when we consider the very great depth at which they have been found living; but it is quite certain that the fossil forms, both of the Oolite and Lias, inhabited comparatively shallow near-shore waters, as is proved by the nature of the deposits in which they occur, and the numerous terrestrial and shallow-water organisms found embedded with them.

The absence of vision in the fossil forms cannot therefore be proved by comparing them with the recent ones, whose conditions and surroundings are so different. The species of *Eryon* from the Lias, having all, apparently, a *diæresis* in the outer lobe of the caudal fan, are evidently an older or less specialized form than those of the newer Solenhofen Stone (Upper Oolite), in which the *diæresis* is absent, the outer lobe of the caudal fan being in one piece; and this is the case also in the surviving deep-sea species.

In a footnote to the "Challenger" Report on *Crustacea-Macrura*, Mr. Spence-Bate writes at p. 120:—"In the Quart. Journ. Geol. Soc. (1866) vol. xxv. fig. 1, Dr. Woodward delineated by the help of the fine examples in the cabinet of the Rev. P. B. Brodie, F.G.S., and those in the British Museum, a completely restored figure of *Eryon barrovensis*, M'Coy, in which the scaphocerite is fixed at the extremity of a peduncle that is independent of that of the antennæ. This condition not being in accordance with the anatomical structure of the Macrurous Decapoda, I am induced to think that the small pedicular plate at the extremity of the third pair of maxillæ is intended, of which a drawing is given, fig. 31, p. 135, in this Report, and which in some recent species extends beyond the frontal margin." In my figure referred to, the artist has correctly represented the projecting latero-anterior angles of the frontal margin of the carapace of *E. Barrovensis* as partially concealing the broad basal joint of the antenna, giving to it *the appearance* as if the antennal scale (scaphocerite) was articulated to a distinct base, separate from the antenna. As such a structure is unknown, it is extraordinary that this should have misled so old and experienced a Carcinologist as Mr. Spence-Bate, and that he should not have turned to the text, where (p. 496,

op. cit.) it is distinctly stated that, "Each of the outer antennæ has a large oval scale attached to its broad basal joint."

It would be quite impossible, in the scope of the present brief article, to discuss the numerous points of interest and importance bearing upon the *Eryonidæ* which the publication of Mr. Spence-Bate's fine Monograph raises, but, I may mention, that in an early Palæontographical Monograph on the British Liassic Crustacea, I hope to treat this subject with the fullness which it deserves.

II.—Fossil Arctic Plants from the Lacustrine Deposit at Hoxne, in Suffolk.[1]

By Clement Reid, F.G.S., and H. N. Ridley, M.A., F.L.S.

Near the village of Hoxne, close to the northern border of Suffolk, and about five miles east of Diss, lies the well-known lacustrine deposit from which Palæolithic implements were obtained more than 90 years ago. This deposit has been so well described that it may seem presumptuous to imagine that there is still anything new to be said about it. But it so happens that every observer up till now has studied the deposit either from an archæological or from a geological point of view. No one has paid special attention to the character of the associated plants, or to the climatic conditions which these plants indicate.

The earliest description of the deposits at Hoxne is an excellent one contained in a letter by John Frere to the Secretary of the Society of Antiquaries.[2] This is dated as far back as 1797. It gives a clear account of the exact mode of occurrence of the implements, and enables us to recognize without difficulty the relative position of the implement-bearing deposits, and of the beds with arctic plants described in this paper.

The section given by Frere is:—

1. Vegetable earth	1½ feet.
2. Argill	7½ ,,
3. Sand mixed with shells and other marine[3] substances	1 foot.
4. A gravelly soil, in which the flints are found, generally at the rate of five or six in a square yard	2 feet.

"In the same stratum are frequently found small fragments of wood, very perfect when first dug up, but which soon decompose on being exposed to the air; and in the stratum of sand (No. 3) were found some extraordinary bones. . . . ." Frere also alludes to the underlying "tract of boggy earth" under No. 4.

The next geological paper dealing with the Hoxne deposit was not published till 1860.[4] In that and the previous year Professor Prestwich visited Hoxne, and very thoroughly worked out the stratigraphical relations of the different beds. To this paper and to a later one published in 1864,[5] we must refer readers for a full

[1] Read at the British Association, Section C, Bath, September, 1888.
[2] Archæologia, vol. xiii. p. 204, 1800, two pp. and two 4to. plates of implements.
[3] This is a mistake, the shells, etc., are freshwater.
[4] Phil. Trans. vol. cl. pp. 304–308, pl. xi.
[5] *Ibid.* cliv. p. 283.

account of the geology, merely quoting one of Prof. Prestwich's sections as an example of the rest, to show which bed contains the Arctic plants:—

Section in S.W. corner of Hoxne Brick-field, 1859.

		feet.
a.	Surface soil, traces of sand and gravel	1 to 2
b.	Brown and greyish clay, not calcareous, with an irregular central carbonaceous or peaty seam. Two flint-implements. Bones of *Bos.*	10 to 12
c.	Yellow sub-angular flint-gravel, with a certain proportion of small chalk pebbles, and a few pebbles of siliceous sandstone, quartz, and other old rocks. *Elephas.* The matrix of this bed, in places, consists of clay like *b*	½ to 1
d.	Bluish and grey calcareous clay, in places very peaty; lower part with seams or partings of sand. *Wood* and vegetable remains. Land and freshwater *shells.* Bones of *Mammalia* (Deer, Horse, Elephant).	3 to 4
e.	Gravel like *c*, but smaller, more worn, and with more chalk pebbles ...	1 to 2½
f.	Calcareous grey clay, more or less peaty, with freshwater *shells* (bored to 17 feet, but no bottom was reached)	17

Other sections showed that the whole deposit rested on Boulder-clay.

From bed *d* Prof. Prestwich obtained wood of Oak (?),[1] Yew and Fir, and subsequently some leaves "apparently of Bilberry" (these belong really to *Salix myrsinites*). He also records the following species of land and freshwater mollusca:—

Pisidium amnicum, Müll.
Sphærium corneum, Linn.
Unio (fragmentary).
Arion ater, Linn. (some calcareous grains)
Bythinia tentaculata, Linn.
Helix hispida? Linn.
Zonites nitidula? Drap.
Limnæa palustris, Linn.
——— *truncatulus*? Linn.
Planorbis albus? Müll.
——— *spirorbis*, Linn.
Succinea putris, Linn.
Valvata piscinalis, Linn.

To this list we can now add, from specimens obtained during our recent visits, *Pisidium fontinale*, var. *Henslowianum*, *Helix rotundatus*, and *Valvata cristata*; also teeth of two genera of freshwater fish—*Esox* and *Leuciscus*.[2]

Mr. Thomas Belt subsequently tried to prove the interglacial age of the implement-bearing loams, laying special stress on the occurrence in the pit in Oakley Park of a small patch of chalky Boulder-clay overlying the loam.[3]

A year or two later Mr. H. B. Woodward and one of the writers of this paper visited Hoxne, and found that there was a little Boulder-clay in the position indicated by Mr. Belt. But the visit made in May of the present year showed the patch more clearly, and it proved to be merely the remains of some clay which had been brought to the pit at an early date—perhaps more than one hundred years ago—when the clay was first dug. This Boulder-clay distinctly rested in one place on the recent vegetable soil.

Numerous references to the implements from Hoxne, and several

[1] Prof. Prestwich informs us that the oak wood was not found by himself, but was obtained from one of the men, who stated that pieces occasionally occur in a very sound condition, like the specimen which he produced. The wood is evidently fossil, but the exact horizon from which it was obtained may have been wrongly observed.

[2] Determined by Mr. E. T. Newton.

[3] Quart. Journ. Sci., n.s. vol. vi. pp. 289-304.

other papers dealing theoretically with the question of the age of the deposit, will be found; but for a record of the facts it is still necessary to go to Professor Prestwich, whose carefully measured sections and clear descriptions of the beds will stand, however our views as to the connection of the Palæolithic deposits with the Glacial beds may change.

Thus far what the writers have seen is strongly in favour of Prof. Prestwich's contention, that the lacustrine deposits rest in a hollow in the Boulder-clay.

The reason for our taking up with this subject was that we had been working for some time at Pre-historic and Pleistocene botany. Looking through the account of the Hoxne deposit we observed that Prof. Prestwich had recorded the plants already mentioned, as either associated with or underlying the implement-bearing beds. We wished to obtain a more complete knowledge of this flora, and to ascertain, if possible, the climatic conditions under which Palæolithic man lived.

At first sight it looks as if the long list of mollusca, or the mammals, ought to settle this question; but they are all species of wide range, and for sensitiveness to climatic changes no class equals the plants.

We, therefore, visited Hoxne last May, and again in July, but found that the digging of the clay had stopped for the season, and that the deeper parts of the pit were full of water. However, there was a large heap of clay, belonging to bed *d*, which had been dug during the winter from one of these flooded pits. This clay showed the lithological character, and the wood, shells, and bilberry-like leaves mentioned by Prof. Prestwich. We took away some of the clay, and on carefully washing and examining the samples after our return to London, we arrived at the somewhat unexpected result that there was a considerable proportion of thoroughly Arctic species among the plants, including such distinctly northern forms as *Salix polaris* and *Betula nana*. The following is a complete list of the plants, as far as we have been able to determine them :—

List of Species Obtained.

Ranunculus aquatilis, L., Fruits.
R. sceleratus, L., Fruit.
R. repens, L., Fruit.
R. Flammula, L., Fruit.
Rubus Idæus, L., Stones.
Comarum palustre, L., Fruits.
Hippuris vulgaris, L., Fruits.
Œnanthe Phellandrium, Lam., Fruits.
Cornus sanguinea, L., one unusually large seed.
Bidens cernua, L., Two fruits.
Ceratophyllum demersum, L., Fruits.
Alnus glutinosa, Gaertn., Cones & Seeds.
Betula nana, L., Leaves.
Salix polaris, Wahlb., A stem, leaves and fruits.
S. myrsinites, L., Leaves and fruit.
Taxus baccata, L., Wood and a seed.
Pinus, sp., Bark.
Sparganium ramosum, L., A whole fruit, and one bitten in two.
Potamogeton pusillus, L., Fruit.
P. trichoides, Cham., Fruit.
P. rufescens, Schrad., Fruit.
P. pectinatus, L., Fruit.
P. crispus, L., Several fruits.
Scirpus lacustris, L., Fruit.
Sc. pauciflorus, Lightf., Fruit.
Eleocharis palustris, L., An imperfect nut.
Carex ampullacea, L., Fruits.
Chara, sp., One nucule.

Mosses.

Brachythecium rutabulum, Bruch. and Schimp.
Amblystegium fluitans, Mitt.
Hylocomnium squarrosum, Schimp.
Campylium stellatum, Mitt.
Acroceratium sarmentosum, Mitt.
A. cuspidatum, Mitt.
Philonotis fontana, Brid.
Webera albicans, Schimp.
Bryum pallens, Sw.
Mnium punctatum, L.

These mosses are all fragments of stems with the leaves attached, and often much decayed. We are indebted to Mr. Mitten for kindly identifying them.

A glance at the list of flowering plants shows that the flora with which we have to deal was an Arctic one, corresponding in some respects to that of Iceland. The presence of the two *Salices* and *Betula nana* is sufficient evidence of this, which is confirmed by the mosses, of which Mr. Mitten remarks that they look like a lot of bits drifted down in a mountain-stream. *Acroceratium sarmentosum* is especially noteworthy as being an Alpine moss, growing in the mountains of Killarney, Scotland, etc.

Salix myrsinites has not hitherto been recorded as a fossil plant. The foliage attributed to "bilberry" in Prof. Prestwich's paper was that of this species, which bears a resemblance to the leaves of a *Vaccinium* on cursory examination. *Cornus sanguinea* is represented by a single seed so large that we were for a long time dubious as to its belonging to this species, but it seems impossible to refer it to any other, and we must conclude it to be merely an unusually large form. The fruits referred to *Œnanthe Phellandrium* are exceptionally small ($\frac{1}{10}$ inch), but otherwise correspond exactly with our recent specimens.

As is usual in these deposits, there is a large proportion of aquatics, and plants which occur on the damp edges of streams and the banks of lakes, whence their seeds have drifted into the mud at the bottom, and nearly all are plants still occurring in high latitudes, but there are several species not truly Arctic, at least at the present day; these are *Taxus baccata, Sparganium ramosum, Cornus sanguinea*, and *Potamogeton trichoides*. *Bidens cernua* is not included in Hooker's distribution of Arctic plants (Trans. Linn. Soc. vol. xxiii. p. 251), but *B. tripartita* is. *B. cernua* however seems to go up north almost as far as *B. tripartita*, though it appears to be less common everywhere. On the other hand, we have *Salix polaris*, only occurring now in very high Arctic latitudes. This species we know from other deposits was much more widely distributed in Glacial and Postglacial times. It has been found in Prussia.

The flora thus suggests the approach of a warmer period following an Arctic one, so that the Arctic flora was not entirely gone by the time that the more temperate one had come.

III.—Further Observations on the Form of Vesuvius and Monte Somma.

By H. J. Johnston-Lavis, M.D., F.G.S., B.-ès-S.

IN the year 1884 a paper of mine, entitled "The Geology of Monte Somma and Vesuvius," was published (Quart. Journ. Geol. Soc. vol. xl. pp. 35 to 119), in which I proposed a new explanation for the peculiarities in form of this volcano. An endeavour was made to show that the truncation of Monte Somma by the series of explosive eruptions, especially of *Phase VI.*, had occurred around an eruptive axis different from that which belonged to the period of vesuvian activity, by which the original Somma cone had been built up. Furthermore, a law was enunciated, which is applicable to a very large number of volcanoes, of which, even in Italy, the following examples may be taken in their order of perfection, viz. Roccamonfina, Mt. Vultura, Etna, Stromboli, Vulcano, and some of the Roman ones. The following are some of the words used: "There is very good reason to deny the concentricity of the great crater of the Atrio with the original cone of Monte Somma. If within a cone we scoop out an inverted conical hollow around an axis eccentric, but parallel, to that of the solid, we shall have the included space bounded by an annular ridge, not horizontal, but sloping down in the direction of the axis of excavation, and inclined proportionally more, the further the axis of excavation is removed from that of the solid.

"It is just with such a condition of things that we have to deal in the present instance. If we measure the distance of the modern eruptive axis (*i.e.* the centre of Vesuvius), from, say, the 650 metres contour-line on the northern slope of Somma, and compare it with that of the same line on the south, we shall find that this axis is between [1] 850 and 950 metres to the south of the centre of the contour-lines of the ancient Somma. In a regular cone, such as we suppose this ancient volcano to have been, the centre of the contour-line would be the eruptive axis of the mountain.

"From these facts we must conclude that although the eruptions that excavated the great crater of the Atrio, and subsequently piled up the cone of Vesuvius, occurred from the same axis, this was nearly a kilometre to the south of the ancient one, of the primary cone of Somma.

"It seems also that the modern axis is slightly displaced to the west of south; but from the obscured features of the ground the exact amount cannot be accurately measured, although it was hardly south-west, as thought by Prof. Phillips.

"This change in the position of the eruptive axis appears to be the most rational explanation of the great difference in height of nearly 500 metres, between the southern and northern ridge of Monte Somma."

I showed that at the same time the hypotheses given by earlier

[1] This is an error of calculation: it should be between 445 and 475.

writers were insufficient to explain the greater truncation of the Somma cone to the south.

Prof. Pasquale Franco last year published a paper, "Il Vesuvio ai tempi di Spartaco e di Strabone," Atti dell' Accad. Pontaniana, vol. xvii., in which my views are severely criticized, and a new hypothesis put forward to explain the lower truncation of Somma to the south.

My critic commences by accusing me of having neglected mentioning that Palmieri had pointed out that in pre-Plinian times the lower edge of Somma was to the south, and he overlooks the fact, that this was so evident to any one who had devoted attention to the subject, that it would have been prolix to mention it again. What I really did was, taking such for granted, to give a rational explanation of the cause of it.

The next objection is raised against my supposition that the cone of Somma was a regular one before its truncation. There is no evidence whatever that it was otherwise, for the following reasons: 1st, It was built up by the constant and regular emission of lava, at any rate while a mantle of from 300 to 400 metres were added to its flanks, as evidenced by the great section of the Atrio, conditions which result in the construction of a fairly symmetrical cone obliterating old irregularities, examples of which we have in the Vesuvian cone itself, Etna, etc. 2nd, The plan of the base of the whole mountain was nearly circular (it is now being deformed and extended by the lavas and alluvions being directed more to its south, east and west sides).

I am then blamed for choosing the 650 contour-line to find the original axis of Somma, and my critic proceeds to try my method on that and eight other contour lines, on a section 40° N. of E. to 40° S. of W., which was not the line I chose, always with the result that the Vesuvian axis is found displaced 430 metres, the minimum displacement being 300 and the maximum 620. My reason for choosing the 650 contour-line was that it is the highest limit of the Atrio crater, or the Somma edge on the south, and as a ridge obviously less exposed to alteration in height than the slopes below, according to well-known mechanical principles of denudation, and the repose of material. The deposits of lava, etc., on this point cannot amount to many metres, whilst on the less inclined slopes below it is demonstrable the lava flows are much thicker, and the alluvial deposits very great indeed, as examination in the field will make more evident than speculation at home. My friend himself admits far greater accumulations on the southern slopes, whereas in the middle zone of the northern slopes of Somma there has been more removal than addition on the whole. This is made strikingly evident by his own table of calculated eccentricities for six contour-lines below the 650, which shows, with one exception, a continuous and progressive diminution in the apparent value of eccentricity, which the author in the third paragraph of page 11 shows a thorough appreciation of. But he immediately contradicts himself in the next statement that there is reason to believe that the denudation was much greater on

the south side than on the north, and doubts what compensation the modern lavas, etc., have given. On the north side, in pre-Plinian times, the upper parts of the mountain of Somma always collected the waters which at lower levels, where the inclination was still great, produced enormous erosion on the northern slopes, as observations in the field clearly demonstrate. But at the same time, after the great crater of the Atrio, after Phase VI., had been filled up, all the water falling on it would either sink in or escape over the lower or southern edge, and not being endowed with that momentum acquired in falling from steep slopes above, could denude little, and would rather soon deposit its rocky burden. Thus there is every evidence that even in pre-Plinian times nature was trying to obliterate that want of symmetry produced by the grand explosive eruption of Phase VI. and their predecessors.

The author then again states his opinion that the old cone of Somma was not a regular one, since he considers that denudation during many centuries of eccentric eruptions (here the author no doubt means those small outbursts with outflow of lava and formation of parasitic cones similar to the 1861 eruption) would have destroyed that regularity. I have already stated my facts for believing that the Somma cone was a regular one, and that so far as denudation goes, that agent of destruction may be entirely neglected, for in an active volcano of the kind under consideration, we should have a surface similar to that of the Vesuvian cone at present, that is, not susceptible of any important change from meteoric agencies. Falling rain immediately sinks into the porous lapilli, and scoriæ, its energy at the moment of impact being chiefly converted into heat. It is only years or centuries after a cone of this kind has become extinct, that vegetation commences to grow on the upper parts of the mountain, and so by rendering the surface less permeable and therefore fit to serve as a water collector. Then, the rain retained on the surface, and rushing down the slopes with considerable momentum, may commence to erode valleys. Nevertheless, the symmetry of a cone is not destroyed, for the valleys that score its sides are roughly equal in size, etc., and symmetrically arranged around it, like the surface between the ribs of a half-opened umbrella.

As to eccentric lava eruptions, the only way in which they modify the symmetry of the cone would be in raising parasitic cones upon its flanks; but surely, the author can hardly deem these worthy of consideration in the question now being considered. Would the numbers of cones and craterets on Etna in any way influence the formation of a crater of explosion?

But to still more strongly confirm what I have asserted, we will choose a part of Monte Somma still uncovered by lavas, and apply the contour-line method. The locality I shall choose is the two strips of the mountain which constitute the Bosco Cognoli, very lately and only in part covered by lava, and which bears a few degrees S. of S.E. from the present axis. It is therefore evident that as this is at an angle of at least 40° with the line of displacement of the eruptive axis, the calculated results of eccentricity should be

much under what they would be in a direction N. and S., or still more W. of S., yet these are the results:—

Contour-line.		Distance of the two axes.
675 metres.	=	400 metres.
650 ,,	=	410
600		460
550		460
500		530
450		540
400		450

If we have such an eccentricity indicated by observation at this point, there evidently must be far more in the azimuth of displacement. But there is still another geological point that makes our figures too low, and that is, that the post-Plinian mantle, and probably the Plinian also, is very thick at B. Cognoli, whereas erosion has been very active on the opposite side of the volcano.

My learned friend then, on geometrical grounds, calculates the proper position of the vertex of Somma, and finds that, adopting the 600 m. contour-line as the southern boundary of the Atrio crater edge, a point opposite and symmetrical would fall outside a vertical line dropped from the crest of Somma. This could hardly be otherwise, as I absolutely reject the 600 contour-line as being the edge of the Atrio crater for reasons I have already and am about to give. Now, strangely enough, when my critic makes use of the 650 metre contour-line, the symmetrical point falls within the vertical line dropped from the crest of Somma, and the author admits that "the theory finds nothing absurd in its application." This, I think, still further confirms me in having chosen the latter contour-line as being the most justifiable to represent the original edge of Somma.

Diagrammatic sketch-section of a cone truncated by a crater formed around an axis eccentric to the original cone.

We then have a description of the figure given (Le Pitture di Ercolano e Contorni IV. p. 343), which is undoubtedly the cone of Monte Somma truncated by the great crater of Atrio, the result of the great explosive eruptions of Phase II., around an eccentric axis. The author then quotes Virgil and other authors, who use words equivalent to the modern Italian "giogaja" or mountain-ridge, which no doubt was the appearance Somma had at that time as seen from Nola; for now, when we look at that mountain from the same

locality, Somma appears as a beautiful symmetrical cone, truncated by a horizontal serrated ridge (well explained by the word "giogaja").

The quotations from the other well-known authors agree quite as well with the geological evidence I have brought forward, as with the figure under consideration, or as these agree together, the one confirming the others. It should be remarked, however, that none of these authors were scientists, or gave any detailed description or references to the mountain.

We then have to deal with another geometrical argument, for the author points out that the plan of the Atrio crater is circular (the interruptions in its limits are so many and so irregular that *circular* is somewhat a far-fetched expression to describe its form), whereas in truncating a regular cone sensibly an ellipse would result. This is perfectly true when we deal with a cone whose slopes are straight, but those of a volcano are curved with a concavity towards the axis. In truncating such a cone, we should not obtain an ellipse, but an ovoid. In truth, in our present consideration, geometrical arguments are of secondary consideration, in comparison to the physical facts concerned. In fact, it is hardly just to assume in one argument that the cone of the old volcano was very far from symmetrical, and to suit another argument to consider it as not only symmetrical, but homogeneous, which system of employing different data is pursued throughout the whole of my critic's memoir. The central core of a volcano is far more dense and compact than the peripheral parts,—first, because it has been exposed to greater superincumbent pressure, and secondly to the intense heat of the neighbouring chimney, which has cemented the fragmentary constituents together into one solid compact mass, such as we see constituting the bottom of the great Atrio section of Monte Somma, whereas towards the periphery, we have simply thin beds of lava, loose scoriæ, ash, etc. It is just this central resistent nucleus which is the probable cause of the eccentricity of explosive eruptions, after long inactivity taking place at some distance from the old axis. When the explosive eruption does take place, it will excavate and erode the part opposite the nucleus with much greater ease. The consequence of this is, that the lower crater edge will be removed further away from the new eruptive axis, so that in plan, it may even appear more distant from that axis, than the upper edge of the crater. This extra destruction of the peripheral part will be greatest near the lowest edge or point most distant from the nuclear part of the volcano, and will diminish, as we approach that part, so that the tendency always is to form a circular and neither an elliptical nor an ovoid-shaped crater. But this is counterbalanced on the northern edge, by subsequent denudation, and crumbling in of the Somma crest. Which of these two influences have been greatest in modifying the original outlines of the mountain, it would be rash to speculate upon. Above all other proofs, however, of the modern eruptive axis being nearer the S. or S.W. slope of the mountain is that all eccentric lava eruptions below the 650 contour-line have taken place within the southern semicircle since those of Phase IV.

Before quitting this part of the subject, there are two observations to make. In the first place, my critic continually makes me say that the Atrio was formed by the explosive eruption known as the Plinian. Now, this is displeasing to me, since I look upon that eruption as of comparatively feeble type, and also because I have stated the direct converse. My words are (*op. cit.* p. 36), "The *eruptions* that excavated the great crater of the Atrio, and *subsequently* piled up the cone of Vesuvius," and I devote nearly 100 pages to describe these eruptions; and again (p. 37, first paragraph), "It (Braeislak's theory) presupposes only one paroxysmal eruption, as the cause of all this great cavity, *whereas a number did the work piecemeal.*" Again, a similar statement is made on p. 65, second paragraph, p. 68, fifth paragraph, and particular attention should be paid to p. 82, fourth paragraph, where I refer the great crater in large part to as far back as the explosive eruption of Phase VI. period 1.

I take this opportunity of mentioning an observation I have made since I wrote my paper, namely, that the slope of the Vesuvian cone is steeper on the N.E. than on the S.W., as if its axis were undergoing gradual displacement in that direction, that is to say, the reverse of what occurred in pre-Plinian and Plinian times. May not the chimney of the volcano not having a straight course, result in this eccentricity consequent upon its being gradually worn so by the constant transmission of fluids through it?

Having to the author's own satisfaction demolished my theory, he proceeds to replace it by one of his own which we will now examine. His theory is that the prevalent wet wind being the *Scirrocco*, or South wind, that impinging on the southern crater ridge has demolished it, leaving the northern intact, and quotes to support his statement the difference in the denudation going on upon the Kasia chain of Sikkim, where in a distance of 20 miles the difference of rainfall is as 1 to 8½. Surely the author would not compare an isolated peak with a high range of mountains. The distance between the two ridges of Somma is not more than four kilometres, yet, we are to believe that the one part of Somma for a height of 500 metres has been swept away, leaving the other portion intact. Moreover, the author fails to take into consideration that for any amount of rainfall to produce a denuding effect, it must be collected together on an impermeable surface, from which it must acquire momentum before it can exert appreciable erosive action. Another fact put forward to support the author's view is that one side of the tower of Notre Dame of Paris is much more weathered than the other, due to prevalent winds. The author would have done better had he been silent upon this, for in the one, we have the result of weathering due to frost, wetting and drying and dissolving the stone, and the other to true surface erosion. If we take the loss of a few millimetres from the surface of Notre Dame during some centuries of exposure of a comparatively soft stone, and then estimate how long a considerable ridge of lavas, scorias, etc., 500 metres high, would require to be denuded at the same rate, we would find that this

action must at least be continued somewhere back in early geological time, and would render any astronomer or physicist most impatient in hurrying geologists up for time. Lastly, where have all the resulting materials gone? for they would be sufficient to entirely change the south slopes of the mountain. Had my critic studied the field geology of that region near the coast, he might observe the pumices of Phase VI. covered only by a few metres of alluvial breccia.

Lastly, if Prof. Franco's explanation was feasible, it should be applicable to all the volcanoes in its neighbourhood. Now, Roccamonfina, which so strikingly resembles Vesuvius in size, shape, and many of its rocks, has the lower lip of its crater of explosion directed to the opposite points of the compass, to that of Monte Somma, but no one would dare assert the prevailing winds to differ at Roccamonfina.

Conclusions.—That the picture discussed by the author is a very fair representation of Somma truncated by an eccentric crater produced by the explosive eruptions of Phase VI.

That ancient writers' accounts correspond fairly well with this figure, and the result of geological investigations.

That the Plinian eruption took place together with its successors around the same axis, as the explosive eruptions of Phase VI.

I would remark that this is a general statement; it is highly probable that not one of the great eruptions were from *exactly the same geometrical* axis; but by saying the *same axis*, I understand approximatively the same for practical considerations. In fact, it is very doubtful if the axis is exactly fixed during the whole period of any one single eruption.

In fine, I am deeply indebted to my friend Prof. Franco for so patiently discussing the historical part of the subject, and for giving us such a rich classical and literary treat, and really hope he will take up some other similar knotty questions bearing on such an interesting geological region.

IV.—British Museum Catalogue of Fossil Reptilia, and Papers on the Enaliosaurians.

By R. Lydekker, B.A., F.G.S., etc.

In writing Part I. of the British Museum Catalogue of Fossil Reptilia, in which a large number of forms are known solely by *disjecta membra*, I was fully prepared to find that many of my determinations, which are frequently provisional, would subsequently need correction. It is, moreover, highly probable that there are really more species represented in the collection than I have indicated, as in some cases, in my desire to avoid the introduction of new specific or generic names which could not be fully substantiated, I have provisionally included under generic or specific headings specimens which may prove to indicate distinct forms. I have lately had the advantage of going over a considerable part of the Dinosaurian collection with Prof. Marsh, who has pointed out to me several erroneous determinations, the most important of which I am

glad to take an early opportunity of correcting. I am also indebted to Dr. Baur for pointing out a less excusable error in regard to the serial position of *Geosaurus*.

At the same time I take the opportunity of adding some observations regarding my papers on the Ichthyopterygia and Sauropterygia published in the July and August numbers of this MAGAZINE, which were written in the hope of inviting criticism of which advantage might be taken in the second part of the Museum Catalogue.

In the diagnosis of the Pythonomorpha, Prof. Cope has been followed; and I have omitted to notice that Prof. Marsh[1] has figured a sternum in one genus. Following Owen[2] and Pictet[3] *Geosaurus* is placed in the Pythonomorpha. Wagner has, however, pointed out its relationship to *Cricosaurus*. In the crushed vertebræ of the type one of the transverse processes has been mistaken for the neural spine; and the apparently procœlous character of some of the centra seems to be due entirely to the effects of pressure. The vertebræ, indeed, are truly Crocodilian; and it seems that the genus (with which *Cricosaurus* is probably identical) should form the type of a distinct subfamily of Crocodilia, characterized by the presence of a sclerotic ring, and the absence of a lateral vacuity in the mandible. This subfamily *Geosaurinæ* should be placed next the subfamily *Metriorhynchinæ* of the *Teleosauridæ*, since the skull of *Cricosaurus* is essentially of the type of that of *Metriorhynchus*; with which genus I had, indeed, proposed to identify it. From the similarity in the teeth it is possible that *Pristichampsa*, of the Lower Eocene, may prove to be a late survivor of the *Geosaurinæ*.

The vertebræ of *Bothriospondylus suffosus* appeared to me to resemble the figure of the vertebra of *Creosaurus*, but Prof. Marsh states that they undoubtedly belong to an immature member of the Sauropoda, which may be identical with one of the Kimeridgian species of *Ornithopsis*. The vertebra of *B. robustus* is probably also referable to the same suborder, and may belong to an immature *Cetiosaurus*.

The two calcanea provisionally referred on p. 225 to *Iguanodon* are also recognized by the same authority as Sauropodous. The teeth provisionally assigned by Sir R. Owen to *Hylæosaurus*, and entered on p. 185 under that heading, Prof. Marsh recognizes as undoubtedly Sauropodous, having some resemblance to those of *Diplodocus*. This would remove any bar to Sir R. Owen's identification of *Regnosaurus* with *Hylæosaurus*; but the former may equally well be identical with the later *Polacanthus*, although probably too large to belong to *Vectisaurus*, on the assumption that the latter belongs to the *Scelidosauridæ*. Assuming that these teeth are truly Sauropodous, the small size of the tooth referred by Phillips (and probably correctly) to *Cetiosaurus Oxoniensis* suggests that they may belong to the smaller *C. brevis*, which would then be proved to differ widely from *Ornithopsis* (? *Pelorosaurus*), which had large teeth.

[1] Amer. Journ. ser. 3, vol. xix. pl. i. (1880).
[2] Odontography, p. 263. It is pointed out that the vertebræ approximate to the Crocodilian type.
[3] Paléontologie, 2nd edition, p. 506.

It is not improbable that the mandibular ramus entered on p. 227 as a young Iguanodont may really indicate a smaller adult form allied to *Laosaurus* or *Camptonotus*, in which event the undetermined femur mentioned on p. 195 may perhaps belong to the same form. I am also inclining to the opinion which was suggested in the Catalogue, that some of the portions of pectoral and pelvic girdles entered under the head of *Iguanodon Bernissartensis* may indicate a second large species of Wealden Iguanodont.

I am further indebted to Prof. Marsh for pointing out that the name *Omosaurus* is preoccupied by Leidy (Proc. Ac. Nat. Sci. Phila. 1856, p. 256). Since, however, the form so designated is known only by the preliminary description, I do not intend to propose a new name; more especially since I think it not improbable that *Stegosaurus* is generically inseparable from *Omosaurus*, in which case the former name should be adopted.

Turning to the Enaliosaurians, Prof. Marsh informs me that *Baptanodon* shows no trace even of a dental groove, and it would therefore seem that Dr. Baur's suggestion as to the generic unity of this form with *Ophthalmosaurus* is not well founded.

In regard to *Plesiosaurus Oxoniensis* (*suprà*, p. 352), a visit to the Oxford Museum, where I have seen the whole of the type-specimens, has shown that the skeletons in Mr. Leeds' collection indicate a form so much superior in size to the type of that species, that I am inclined to think it will be safe for the present to retain for them the name of *P. eurymerus*, although I can see no structural difference in the vertebræ. Both the pectoral girdle and the limb-bones figured by Phillips under the former name are from a different locality from the vertebral column, and I now think are probably both referable to *P. plicatus*. This pectoral girdle when entire was of the type of that of the so-called *Elasmosaurus*. In these notes I have used the term *Plesiosaurus* in its wider sense. With regard to *P. philarchus*, which I was inclined to include in *Thaumatosaurus*, I have since seen reasons which have induced me to regard this form as indicating a new genus connecting *Thaumatosaurus* with *Pliosaurus*.

Finally, I must offer my apologies to Prof. Cope for the statement regarding *Elasmosaurus* (*suprà*, p. 356). In a separate copy in the Museum Library of the memoir to which I have alluded the figure of the skeleton is given in the reversed manner I have mentioned. This copy belongs, however, to an advance issue, of which, I am informed, the greater portion was suppressed, and in the serial itself the erroneous restoration and the accompanying letterpress have been amended.

V.—An Undescribed Carboniferous Fossil.

By Prof. T. Rupert Jones, F.R.S., and Dr. Hy. Woodward, F.R.S.

In the Museum of Practical Geology, London, is a remarkable specimen, marked D $\frac{36}{2}$, which the late Mr. J. W. Salter referred to, in the 'Quart. Journ. Geol. Soc.' vol. xix. 1863, p. 92, as "a huge bivalve Crustacean," . . . "with a carapace 7 inches long," giving it the name "*Dithyrocaris pholadomya*." It is in a dark micaceous

sandstone, from the "Carboniferous Shales" (or Lower Limestone of the Carboniferous-Limestone series), of Berwick-upon-Tweed. In the "Catalogue of the Collection of Fossils in the M.P.G.," 1865, p. 116, it is referred to as "*Dithyrocaris pholadiformis*"; but whether or no this specific name was an alteration made by Mr. Salter himself is doubtful.

The specimen consists of two counterparts, one on each moiety of the split slab, showing impressions of the outside of one, and of a part of the inside of the other valve.

"Seven inches" was evidently not the whole length of this extraordinary bivalved specimen, for probably more than an inch has been broken off at one end. Its width (height) is not wholly seen, for one valve (lying uppermost), broken away from the other, is shifted upwards to some extent over the perhaps more perfect dorsal edge of the other valve, and thus has lost probably a quarter or half an inch in that dimension. See woodcut, Fig. 1; half

Fig. 1. *Salterella pholadiformis*, Lower Limestone Shales, Carboniferous Series, Berwick-on-Tweed.

natural size. As it lies in the stone, it has a boat-shaped outline, with an almost symmetrically elliptical curve on the lower border. The back, or upper edge, may have been either straight, or slightly convex, in its middle two-fourths; but it sloped downwards at a low angle towards the extremities on each of its terminal fourths. Hence, both in front and behind, at the junction of the two dorsal edges, there would be a slope, if the fossil were of a real bivalved form; or a narrow slit, if the valves lay open, or if it were originally buckler-shaped, but since folded up. Numerous concentric lines of growth run parallel with the free edges; they are irregular in their thicknesses, and are thrown into undulations by about twelve transverse, radiating furrows and ridges of the valves. These flexures are more strongly pronounced on that moiety of the valve which happens to be more perfect than the other.

The underlying valve or lateral moiety shows the lower part of the inner surface, below the outer or lower edge of the valve that lies uppermost. It shows longitudinal, concentric lines and transverse undulations, similar to those on the other (overlying) valve. Some matrix lies between the valves, as shown by a narrow seam of broken sandstone.

That this large and apparently once thin and tough bivalved specimen should have been referred to by Mr. Salter as belonging probably to the Phyllopoda would go far to induce us to support his view, if we knew of any analogous form among that group. As a bivalved Crustacean, however, the apparently equal ends of the valves, and their radiating furrows, are out of place or quite abnormal. If looked at as an Apudiform or buckler-shaped form, folded down the middle, the same objections occur. The probable slit at each end would serve for either case, though not quite fitting with the latter.

It is less difficult to find an analogue for this specimen among the Bivalved Molluscs. Thus *Siliqua radiata*, Linn., has a straight, feeble hinge-line, and concentric striæ, but radiating colour-lines instead of furrows. In *Soletellina violacea*, Lamarck, the hinge and umbo are stronger than in the foregoing; there are concentric striæ, and the radiating faint, colour-lines, are slightly raised. Both *Pholas* and *Pholadomya*, of course, have transverse ridges and furrows somewhat analogous to those of our fossil, but their other features do not coincide. *Clidophorus* has a straight hinge and radiating riblets; but the latter start from an umbo near one end; and the valves have a shape different from that of the specimen under notice.

Having thus noticed this interesting specimen, we must for the present leave its more definite generic relations indeterminate, hoping that fresh material may turn up through the energy of local observers and collectors whose attention is now again called to it. Although at present the position of this fossil must remain doubtful. yet, for the sake of convenience of reference and cataloguing, it may in future be known as *Salterina pholadiformis*, Salter, sp.

VI.—Additional Note on the Blue Hornblende of Mynydd Mawr.

By Alfred Harker, M.A., F.G.S.,
Fellow of St. John's College, Cambridge.

In the short description of the Mynydd Mawr rock given in the May Number of this Magazine (p. 221), I drew attention to a remarkable blue hornblende, which I was unable to refer to any known variety. In the character of its absorption and pleochroism it differed widely from both glaucophane and arfvedsonite, although allied to them in some of its properties, such as its extreme fusibility, splinters melting easily in the flame of a candle.

A paper by Dr. Sauer of Leipzig, which has just appeared,[1] throws considerable light on the subject, and makes it appear that we have here a new mineral of considerable interest. Among the rocks collected in the island of Socotra by the late Dr. Riebeck is a pink felspar-granite containing black crystals up to 5 mm. in length. This is the mineral which has been named *Riebeckite* in honour of the traveller, and which presents the closest resemblance to that occurring in the quartz-porphyry of Mynydd Mawr. It has been

[1] Zeitsch. d. Deutsch. geol. Gesellsch. vol. xl. p. 138, 1888.

examined optically by Prof. Rosenbusch, who writes as follows: "It was determined on more than 20 cleavage-flakes, that the axis of elasticity which makes an angle of only about 5° with c is a, not γ, as in the [other] amphiboles; its colour is dark blue; $b=\beta$, a rather less deep blue; γ, which is almost perpendicular to c, =green. Axial angle large. The characters are thus surprisingly like those of aegirine among the pyroxenes." That riebeckite holds chemically, as well as optically, the same place among the amphiboles as aegirine does among the pyroxenes, appears from Sauer's analysis. Compared with arfvedsonite, it shows more silica, much more ferric, and less ferrous oxide. Taking account of all its characters, there can be no reasonable doubt that the Mynydd Mawr mineral is riebeckite.

The blue tourmaline which I described, not without misgivings, as accompanying the blue hornblende, is, in all probability, the same mineral. Owing to the almost opaque nature of the sections, I was reduced to experimenting on the minute and impure crystals with a knife and a candle-flame; so perhaps the mistake was a pardonable one; the more so, as Professor Bonney, who has pointed it out to me, appears to have been himself deceived by the Socotra riebeckite, regarding it as a pseudomorph of tourmaline after hornblende.[1] His figure closely resembles the slides from Mynydd Mawr.

Besides the larger crystals of riebeckite, Sauer finds in the Socotra granite microlites of the same mineral, precisely similar to the colourless and pale-blue microlites already described in the rock of Mynydd Mawr. That these belong to riebeckite, rather than to tourmaline, is proved by the direction of maximum absorption being parallel, not perpendicular, to the long axis. Sauer regards them as due, at least in part, to the secondary alteration of the felspar. This last suggestion cannot be maintained in the case of the Welsh rock. Apart from chemical difficulties, the mode of occurrence of the microlites, and especially their fluxional disposition through the ground-mass, show them to be original constituents of the rock.

NOTICES OF

I.—British Association for the Advancement of Science.

Bath Meeting, September 5th to 12th, 1888.

List of Titles of Papers read before Section C. Geology.

Professor W. Boyd Dawkins, M.A., F.R.S., F.G.S., President.

The President's Address. (See infra p. 459.)

Horace B. Woodward.—Further Note on the Midford Sands. (p. 470.)

Horace B. Woodward.—The Relations of the Great Oolite to the Forest Marble and Fuller's Earth in the South-west of England. (See infra p. 467.)

Horace B. Woodward.—Note on the Portland Sands of Swindon, etc. (See infra p. 469.)

O. W. Jeffs.—On Geological Photography.

[1] Phil. Trans. vol. clxxiv. part i. p. 283, 1873.

Dr. C. Callaway.—Further Notes on the Origin of the Crystalline Schists of Malvern and Anglesey.

Dr. C. Callaway.—Sketch of the Geology of the Crystalline Axis of the Malvern Hills.

Dr. Persifor Frazer.—Archæan Characters of the rocks of the Nucleal Ranges of the Antilles.

Dr. Persifor Frazer.—Oligoclase and Quartz with curious Optical Properties.

Dr. H. W. Crosskey.—Report on Erratic Blocks.

Dr. H. W. Crosskey—On a High Level Boulder-clay in the Midlands.

W. Whitaker.—On the Extension of the Bath Oolite under London, as shown by a deep boring at Streatham.

E. Wethered.—On the Lower Carboniferous Rocks of Gloucestershire.

Rev. H. H. Winwood.—On the Tytherington Section to be seen on Saturday's Excursion.

Handel Cossham, M.P.—The Northern Section of the Bristol Coal Field.

W. A. E. Ussher.—Some points of interest in the Geology of Somerset.

Prof. O. C. Marsh.—Comparison of the Principal Forms of Dinosauria of Europe and America.

H. F. Osborn.—The Evolution of the Mammalian Molar teeth to and from the tritubercular type.

Professor A. Gaudry.—On the great size of some Fossil Mammals.

Rev. Dr. A. Irving.—Note on the Relation of the Percentage of Carbonic Acid in the Atmosphere to the Life and Growth of Plants.

James Spencer.—On the Occurrence of a Boulder of Granitoid Gneiss or Gneissoid Granite in the Halifax Hard Bed Coal.

Chev. R. E. Reynolds.—The Caverns of Luray.

W. Topley.—Report on the rate of Erosion of the Sea Coasts of England and Wales.

Dr. Tempest Anderson.—The Volcanoes of the Two Sicilies. (p. 473.)

Dr. H. J. Johnston-Lavis.—Notes on the recent Volcanic Eruption in the Island of Vulcano.

Dr. H. J. Johnston-Lavis.—Report on the Volcanic Phenomena of Vesuvius.

Dr. H. J. Johnston-Lavis.—On the Conservation of Heat in Volcanic Chimneys.

Dr. H. J. Johnston-Lavis.—Note on a Mass containing Metallic Iron found on Vesuvius.

Dr. H. J. Johnston-Lavis.—Note on the Occurrence of Leucite at Etna.

Prof. E. W. Claypole.—Note on Some Recent Investigations into the Condition of the Interior of the Earth.

J. Logan Lobley.—On the Causes of Volcanic Action.

Professor John Milne.—Report on the Volcanic Phenomena of Japan.

O. H. Howarth.—On the recent Volcanic Structure of the Azorean Archipelago. (See infra p. 472.)

Professor G. A. Lebour.—Report of the Earth-Tremor Committee.

W. A. E. Ussher.—The Watcombe Terra-Cotta Clay.

A. Bell.—Report on the "Manure Gravels" of Wexford.

T. W. Shore.—Beds exposed in the Southampton New Dock Excavation.

Clement Reid and H. N. Ridley.—Fossil Arctic Plants from the Lacustrine Deposit at Hoxne. (Printed in full, see supra p. 441.)

G. W. Lamplugh.—Report on an Ancient Sea Beach near Bridlington.

Professor H. G. Seeley.—On the Origin of Oolitic Structure in Limestone Rock.

Professor F. Bassani.—Notes of some Researches on the Fossil Fishes of Chiavòn, Vicentino.

Professor T. Rupert Jones.—Report upon the Fossil Phyllopoda of the Palæozoic Rocks.

Professor W. C. Williamson.—Report on the Flora of the Carboniferous Rocks of Lancashire and West Yorkshire.

Professor H. G. Seeley.—On an *Ichthyosaurus* from Mombasa; with observations on the Vertebral Characters of the Genus.

A. Smith Woodward.—A comparison of the Cretaceous Fish-fauna of Mount Lebanon with that of the English Chalk. (See infra p. 471.)

A. Smith Woodward.—On *Bucklandium diluvii*, König, a Siluroid Fish from the London Clay of Sheppey. (See infra p. 471.)

Rev. Dr. A. Irving.—On the Origin of Graphite in the Archæan Rocks, with a review of the alleged evidence of Life on the Earth in Archæan Time.

Rev. G. F. Whidborne.—On some Devonian Cephalopods and Gasteropods.

Rev. G. F. Whidborne.—On some Devonian Crustaceans.

Rev. G. F. Whidborne.—On some Fossils of the Limestones of South Devon.

T. Sterry Hunt.—Mineralogical Evolution.

Professor J. F. Blake.—Report upon the Microscopic Structure of the Older Rocks of Anglesey.

Dr. C. Ricketts.—On a Probable Cause of Contortions of Strata.

J. Joly.—On the Temperature at which Beryl is Decolorized.

J. Joly.—On the Occurrence of Iolite in the Granite of Co. Dublin.

W. W. Watts.—An Igneous Succession in Shropshire.

C. E. De Rance.—Report on the Circulation of Underground Waters in the Permeable Formations of England.

W. H. Dalton.—A List of Works referring to British Mineral and Thermal Waters.

Titles of Papers Read before Section D. (Biology) bearing upon Geology.

Professor O. C. Marsh.—Restoration of *Brontops robustus*, from the Miocene of America.

Dr. S. J. Hickson and G. C. Bourne.—Discussion on Coral-Reefs.

Dr. H. Gadow.—The Nature of the Geological terrain as an important factor in the Geographical Distribution of Animals.

C. A. Barber.—On *Pachytheca*, a Silurian Alga of doubtful affinities.

II.—Address to the Geological Section of the British Association, Bath, 1888. By W. Boyd Dawkins, M.A., F.R.S., F.G.S., F.S.A., Professor of Geology and Palæontology in Owens College, President of the Section.

IN taking the chair occupied twenty-four years ago in this place by my honoured master, Professor Phillips, I have been much perplexed as to the most fitting lines on which to mould my Address. It was open to me to deal with the contributions to our knowledge since our last meeting in Manchester in such a manner as to place before you an outline of our progress during the last twelve months. But this task, difficult in itself, is rendered still more so by the special circumstances of this meeting, attended, as it is, by so large a number of distinguished geologists, assembled from nearly every part of the world for the purposes of the Geological Congress. It would be presumptuous of me, in the presence of so many specialists, to attempt to summarize and co-ordinate their work. Indeed, we stand too near to it to be able to see the true proportions of the various parts. I will merely take this opportunity of offering to our visitors, in the name of this section and of English geologists in general, a hearty welcome to our shores, feeling that not only will our science be benefited enormously by the simplification of geological nomenclature, but that we ourselves shall derive great advantage by a closer personal contact with them than we have enjoyed hitherto.

Our science has made great strides during the last twenty-four years, and she has profited much from the great development of her sisters. The microscopic analysis of the rocks has opened out a new field of research, in which physics and chemistry are in friendly rivalry, and in which fascinating discoveries are being made almost day by day as to metamorphism, and the crushing and shearing forces brought to bear upon the cooling and contracting crust while the earth was young. The deep-sea explorations have revealed the structure and the deposits of the ocean abysses, and the depths supposed to be without life, like the fabled deserts in the interior of Africa, are now known to teem with varied forms glowing with the richest colours. From a comparison of these deposits with the stratified rocks, we may conclude that the latter are marginal, and deposited in depths not greater than 1000 fathoms, or the shore end of the Globigerina ooze, and most of them at a very much less depth, and that consequently there is no proof in the geological record of the ocean depths having ever been in any other than their present places.

In North America the geological survey of the Western States has brought to light an almost unbroken series of animal remains, ranging from the Eocene down to the Pleistocene age. In these we find the missing links in the pedigree of the Horse, and sufficient evidence of transitional forms to cause Professor Flower to restore to its place in classification the order Ungulata of Cuvier. These may be expected to occupy the energies of our kinsmen on the other side of the Atlantic for many years, and to yield further proof of the truth of the doctrine of Evolution. The use of this word reminds me how

much we have grown since 1864, when evolution was under discussion, and when biological, physical, and geological laboratories could scarcely be said to have existed in this country. Truly may the scientific youth of to-day make the boast

Ἡμεῖς μὲν πατέρων μέγ' ἀμείνονες εὐχόμεθ' εἶναι—

"We are much better off than our fathers were," while we, the fathers, have the poor consolation of knowing that when they are fathers, their children will say the same of them. There is reason to suppose that our science will advance more swiftly in the future than it has in the past, because it has more delicate and precise methods of research than it ever had before, and because its votaries are more numerous than they ever were.

In 1864 the attention of geologists was mainly given to the investigations of the later stages of the Tertiary period. The bent of my pursuits inclines me to revert to this portion of geological inquiry, and to discuss certain points which have arisen during the last few years in connection with the classificatory value of fossils, and the mode in which they may be best used for the co-ordination of strata in various parts of the world.

The principle of homotaxy, first clearly defined by Professor Huxley, has been fully accepted as a guiding principle in place of synchronism or contemporaneity, and the fact of certain groups of plants and animals succeeding one another in a definite order, in countries remote from each other, is no longer taken to imply that each was living in the various regions at the same time, but rather, unless there be evidence to the contrary, that they were not. While, however, there is a universal agreement on this point among geologists, the classificatory value of the various divisions of the vegetable and animal kingdoms is still under discussion, and, as has been very well put by my predecessor in this chair at Montreal, sometimes the evidence of one class of organic remains points in one direction, while the evidence of another class points in another and wholly different direction as to the geological horizon of the same rocks. The Flora, put into the witness-box by the botanist, says one thing, while the Mollusca or the Vertebrata say another thing in the hands of their respective counsel. There seems to be a tacit assumption that the various divisions of the organic world present the same amount of variation in the rocks, and that consequently the evidence of every part of it is of equal value.

It will not be unprofitable to devote a few minutes to this question, premising that each case must be decided on its own merits, without prejudice, and that the whole of the evidence of the flora and fauna must be considered. We will take the flora first.

The cryptogamic flora of the later Primary rocks shows but slight evidence of change. The forests of Britain and of Europe generally, and of North America, were composed practically of the same elements—Sigillaria, Calamites, and Conifers allied to the Ginkho—throughout the whole of the Carboniferous (16,336 feet in thickness in Lancashire and Yorkshire) and Devonian rocks, and do not present greater differences than those which are to be seen in the existing

forests of France and Germany. They evidently were continuous both in space and time, from their beginning in the Upper Silurian to their decay and ultimate disappearance in the Permian age. This disappearance was probably due to geographical and climatic changes, following the altered relations of land to sea at the close of the Carboniferous age, by which Secondary plants, such as *Voltzia* and *Walchia*, were able to find their way by migration from an area hitherto isolated. The Devonian formation is mapped off from the Carboniferous, and this from the Permian, but to a slight degree by the flora, and nearly altogether by the fauna. While the fauna exhibits great and important changes, the flora remained on the whole the same.

The forests of the Secondary period, consisting of various Conifers and Cycads, also present slight differences as they are traced upwards through the Triassic and Jurassic rocks, while remarkable and striking changes took place in the fauna, which mark the division of the formations into smaller groups. As the evidence stands at present, the Cycads of the Lias do not differ in any important character from those of the Oolites or the Wealden, and the *Salisburia* in Yorkshire in the Liassic age is very similar to that of the Island of Mull in the Early Tertiary, and to that (*Salisburia adiantifolia*) now living in the open air in Kew Gardens.

Nor do we find evidence of greater variation in the dicotyledonous forests, from their first appearance in the Cenomanian stage of the Cretaceous rocks of Europe and America, through the whole of the Tertiary period down to the present time. In North America the flora of the Dakota series so closely resembles the Miocene of Switzerland that Dr. Heer has no hesitation in assigning it in the first instance to the Miocene age. It consists of more than one hundred species, of which about one-half are closely allied to those now living in the forests of North America—Sassafras, Tulip, Plane, Willow, Oak, Poplar, Maple, Beech, together with *Sequoia*, the ancestor of the giant Redwood of California. The first Palms also appear in both continents at this place in the Geological record.

In the Tertiary period there is an unbroken sequence in the floras, as Mr. Starkie Gardner has proved, when they are traced over many latitudes, and most of the types still survive at the present day, but slightly altered. If, however, Tertiary floras of different ages are met with in one area, considerable differences are to be seen, due to progressive alterations in the climate and altered distribution of the land. As the temperature of the Northern Hemisphere became lowered, the tropical forests were pushed nearer and nearer to the Equator, and were replaced by plants of colder habit from the northern regions, until ultimately, in the Pleistocene age, the Arctic plants were pushed far to the south of their present habitat. In consequence of this Mr. Gardner concludes that "it is useless to seek in the Arctic regions for Eocene floras as we know them in our latitudes, for during the Tertiary Period the climatic conditions of the earth did not permit their growth there. Arctic fossil floras of temperate and therefore Miocene aspect are in all probability

of Eocene age, and what has been recognized in them as a newer or Miocene facies is due to their having been first studied in Europe in latitudes which only became fitted for them in Miocene times. When stratigraphical evidence is absent or inconclusive, this unexpected persistence of plant types or species throughout the Tertiaries should be remembered, and the degrees of latitude in which they are found should be well considered before conclusions are published respecting their relative age."

This view is consistent with that held by the leaders in botany, Hooker, Dyer, Saporta, Dawson, and Asa Gray—whose recent loss we so deeply deplore—that the North Pole region is the centre of dispersal, from which the Dicotyledons spread over the Northern Hemisphere. If it be true—and I, for one, am prepared to accept it—it will follow that for the co-ordination of the subdivisions of the Tertiary strata in various parts of the world, the plants are uncertain guides, as they have been shown to be in the case of the Primary and Secondary rocks. In all cases where there is a clash of evidence, such as in the Laramie lignites, in which a Tertiary flora is associated with a Cretaceous fauna, the verdict in my opinion must go to the fauna. They are probably of the same geological age as the deposit at Aix-la-Chapelle.

I would remark further, before we leave the floras behind us, that the migration of new forms of plants into Europe and America took place before the arrival of the higher types in the fauna, after the break-up of the land at the close of the Carboniferous period, after the great change in geography at the close of the Neocomian. The Secondary Plants preceded the Secondary Vertebrates by the length of time necessary for the deposit of the Permian rocks, and the Tertiary Plants preceded the Tertiary Vertebrates by the whole period of the Upper Cretaceous.

Let us now turn to the fauna.

Professor Huxley, in one of his many addresses which have left their mark upon our science, has called attention to the persistence of types revealed by the study of Palæontology, or, to put it in other words, to the singularly little change which the ordinal groups of life have undergone since the appearance of life on the earth. The species, genera, and families present an almost endless series of changes, but the existing orders are for the most part sufficiently wide, and include the vast series of fossils without the necessity of framing new divisions for their reception. The number of these extinct orders is not equally distributed through the animal kingdom. Taking the total number of orders at 108, the number of extinct orders in the Invertebrata amounts only to 6 out of 88, or about seven per cent., while in the Vertebrates it is not less than 12 out of 40, or 30 per cent. These figures imply that the amount of ordinal change in the fossil Vertebrates stands to that in the Invertebrata in the ratio of 30 to 7. This disproportion becomes still more marked when we take into account that the former has less time for variation than the latter, which had the start by the Cambrian and Ordovician periods. It follows also that as a whole they have changed faster.

The distribution of the extinct orders in the animal kingdom, taken along with their distribution in the rocks, proves further that some types have varied more than others, and at various places in the geological record. In the Protozoa, Porifera, and Vermes there are no extinct orders; among the Cœlenterates one, the Rugosa; in the Echinodermata three, Cystideans, Edriasterida, and Blastoidea; in the Arthropoda two, the Trilobita and Eurypterida. All these, with the solitary exception of the obscure order Rugosa, are found only in the Primary rocks. Among the Pisces there are none; in the Amphibia one, the Labyrinthodonts ranging from the Carboniferous to the Triassic age. Among the Reptilia there are at least six of Secondary age, Plesiosauria, Ichthyosauria, Dicynodontia, Pterosauria, Theriodontia, Dinosauria; in the Aves two, the Saururæ and Odontornithes, also Secondary. In the Mammalia the Amblypoda, Tillodontia, Condylarthra, and Toxodontia represent the extinct orders—the first three Early Tertiary, and the last Pleistocene. It is clear, therefore, that while the maximum amount of ordinal variation is presented by the Secondary Reptilia and Aves, all the extinct orders in the Tertiary are Mammalian.

If we turn from the extinct orders to the extinct species, it will also be found that the maximum amount of variation is presented by the plants, and all the animals, excepting the Mammalia, in the Primary and Secondary periods.

The general impression left upon my mind by these facts is that, while all the rest of the animal kingdom had ceased to present important modifications at the close of the Secondary period, the Mammalia, which presented no great changes in the Secondary rocks, were, to quote a happy phrase of Professor Gaudry, "en pleine évolution" in the Tertiary age. And when, further, the singular perfection of the record allows us to trace the successive and gradual modifications of the Mammalian types from the Eocene to the close of the Pleistocene Age, it is obvious that they can be used to mark subdivisions of the Tertiary Period, in the same way as the reigns of kings are used to mark periods in human history. In my opinion they mark the geological horizon with greater precision than the remains of the lower members of the animal kingdom, and in cases such as that of Pikermi, where typical Miocene forms, such as Dinotheria, are found in a stratum above an assemblage of marine shells of Pliocene age, it seems to me that the Mammalia are of greater value in classification than the Mollusca, some of the species of which have been living from the Eocene down to the present day.

Yet another important principle must be noted. The fossils are to be viewed in relation to those forms now living in their respective geographical regions. The depths of the ocean have been where they are now since the earliest geological times, although continual geographical changes have been going on at their margins. In other words, geographical provinces must have existed even in the earlier geological periods, although there is reason to believe that they did not differ so much from each other as at the present day. It follows from this that the only just standard for comparison in

dealing with the fossils, and especially of the later rocks, is that which is offered by the fauna and flora of the geographical province in which they are found. The non-recognition of this principle has led to serious confusion. The fauna, for example, of the Upper Sivalik Formation has been very generally viewed from the European standpoint, and placed in the Miocene, while, judged by the standpoint of India, it is really Pliocene. A similar confusion has followed from taking the Miocene flora of Switzerland as a standard for the Tertiary flora of the whole of the Northern Hemisphere.

It now remains for us to see how these principles may be applied to the co-ordination of Tertiary strata in various parts of the world. In 1880 I proposed a classification of the European Tertiaries, in which, apart from the special characteristic fossils of each group, stress was laid on the gradual approximation of various groups to the living Mammalia. The definitions are the following:—

Divisions.	Characteristics.
1. Eocene, or that in which the higher Mammals (Eutheria) now on the earth were represented by allied forms belonging to existing orders and families. Oligocene.	Extinct orders. Living orders and families. No living genera.
2. Miocene, in which the alliance between fossil and living Mammals is closer than before.	Living genera. No living species.
3. Pliocene, in which living species of Mammals appear.	Living species few. Extinct species predominant.
4. Pleistocene, in which living species of Mammals preponderate.	Living species abundant. Extinct species present. Man present.
5. Prehistoric, or that period outside history in which Man has multiplied exceedingly on the earth and introduced the domestic animals.	Man abundant. Domestic animals present. Wild Mammals in retreat. One extinct Mammal.
6. Historic, in which the events are recorded in history.	Records.

These definitions are of more than European significance. The researches of Leidy, Marsh and Cope prove that they apply equally to the Tertiary strata of North America. The Wasatch Bridger and Uinta strata contain representatives of the orders Cheiroptera and Insectivora, the suborders Artio- and Perissodactyla, and the families Vespertilionidæ and Tapiridæ; but no living genera.[1] The Mammalia are obviously in the same stage of evolution as in the Eocenes of Europe, although there are but few genera, and no species common to the two.

[1] The genus *Vesperugo* has not been satisfactorily determined. Cope, Report of Geological Survey of the Territories, Tertiary Vertebrata, vol. i. 1884.

The White River and Loup Fork Groups present us with the living genera *Sciurus*, *Castor*, *Hystrix*, *Rhinoceros*, *Dicotyles*, and others; but no living species, as is the case with the Miocenes of Europe. In the Pliocenes of Oregon the first living species appear, such as the Beaver, the Prairie Wolf, and two Rodents (*Thomomys clusius* and *T. talpoides*), while in the Pleistocene river deposits and caves, from Eschscholtz Bay in the north to the Gulf of Mexico in the south, there is the same grouping of living with extinct species as in Europe, and the same evidence in the glaciated regions that the Mammalia occupied the land after the retreat of the ice.

If we analyze the rich and abundant fauna yielded by the caves and river deposits both of South America and of Australia, it will be seen that the Pleistocene group in each is marked by the presence of numerous living species in each, the first being remarkable for their gigantic extinct Edentata, and the second for their equally gigantic extinct Marsupials.

The admirable work of Mr. Lydekker allows us also to see how these definitions apply to the fossil Mammalia of India. The Miocene fauna of the Lower Sivaliks has yielded the living genera *Rhinoceros* and *Manis*, and no living species.

The fauna of the Upper Sivaliks, although it has only been shown, and that with some doubt, to contain one living Mammal, the Nilghai (*Boselaphus tragocamelus*), stands in the same relation to that of the Oriental region, as that of the Pliocenes of Europe to that of the Palæarctic region, and is therefore Pliocene. And lastly, the Narbada formation presents us with the first traces of Palæolithic Man in India in association with the living one-horned Rhinoceros, the Nilghai, the Indian Buffalo, two extinct Hippopotami, Elephants, and others, and is Pleistocene.

It may be objected to the Prehistoric and Historic divisions of the Tertiary Period that neither the one nor the other properly fall within the domain of Geology. It will, however, be found that in tracing the fauna and flora from the Eocene downwards to the present day there is no break which renders it possible to stop short at the close of the Pleistocene. The living plants and animals were in existence in the Pleistocene age in every part of the world which has been investigated. The European Mollusca were in Europe in the Pliocene age. The only difference between the Pleistocene fauna, on the one hand, and the Prehistoric, on the other, consists in the extinction of certain of the Mammalia at the close of the Pleistocene age in the Old and New Worlds, and in Australia. The Prehistoric fauna in Europe is also characterized by the introduction of the ancestors of the present domestic animals, some of which, such as the Celtic shorthorn (*Bos longifrons*), Sheep, Goat, and domestic Hog, reverted to a feral condition, and have left their remains in caves, alluvia, and peat-bogs over the whole of the British Isles and the Continent. These remains, along with those of Man in the Neolithic, Bronze, and Iron stages of culture, mark off the Prehistoric from the Pleistocene strata. There is surely no reason why a cave used by Palæolithic Man should be handed over to the geologist,

while that used by men in the Prehistoric age should be taken out of his province, or why he should be asked to study the lower strata only in a given section, and leave the upper to be dealt with by the archæologist. In these cases the ground is common to geology and archæology, and the same things, if they are looked at from the standpoint of the History of the Earth, belong to the first, and, if from the standpoint of the history of Man, to the second.

If, however, there be no break of continuity in the series of events from the Pleistocene to the Prehistoric ages, still less is there in those which connect the Prehistoric with the period embraced by history. The Historic date of a cave or of a bed of alluvium is as clearly indicated by the occurrence of a coin as the geological position of a stratum is defined by an appeal to a characteristic fossil. The gradual unfolding of the present order of things from what went before compels me to recognize the fact that the Tertiary Period extends down to the present day. The Historic period is being recorded in the strata now being formed, exactly in the same way as the other divisions of the Tertiary have left their mark in the crust of the earth, and history is incomplete without an appeal to the geological record. In the masterly outline of the description of Roman civilization in Britain the historian of the English Conquest was obliged to use the evidence, obtained from the upper strata, in caves which had been used by refugees from the cities and villas; and among the materials for the future history of this city there are, to my mind, none more striking than the proof, offered by the silt in the great Roman bath, that the resort of crowds had become so utterly desolate and lonely in the ages following the English Conquest as to allow of the nesting of the Wild Duck.

I turn now to the place of Man in the geological record, a question which has advanced but little since the year 1864. Then, as now, his relation to the Glacial strata in Britain was in dispute. It must be confessed that the question is still without a satisfactory answer, and that it may well be put to "a suspense account." We may, however, console ourselves with the reflection that the River-drift Man appears in the Pleistocene strata of England, France, Spain, Italy, Greece, Algiers, Egypt, Palestine, and India along with Pleistocene animals, some of which were pre-Glacial in Britain. He is also proved to have been post-Glacial in Britain, and was probably living in happy, sunny, southern regions, where there was no ice, and therefore no Glacial period, throughout the Pleistocene age.

It may further be remarked that Man appears in the geological record where he might be expected to appear. In the Eocene the Primates were represented by various Lemuroids (*Adapis*, *Necrolemur*, and others) in the Old and New Worlds. In the Miocene the Simiadæ (*Dryopithecus*, *Pliopithecus*, *Oreopithecus*) appear in Europe, while Man himself appears, along with the living species of Mammalia, in the Pleistocene age, both in Europe and in India.

The question of the antiquity of Man is inseparably connected with the further question: "Is it possible to measure the lapse of geological time in years?" Various attempts have been made, and

all, as it seems to me, have ended in failure. Till we know the rate of causation in the past, and until we can be sure that it has been invariable and uninterrupted, I cannot see anything but failure in the future. Neither the rate of the erosion of the land by subaërial agencies, nor its destruction by oceanic currents, nor the rate of the deposit of stalagmite or of the movement of glaciers, have as yet given us anything at all approaching a satisfactory date. We only have a sequence of events recorded in the rocks, with intervals the length of which we cannot measure. We do not know the exact duration of any one geological event. Till we know both, it is surely impossible to fix a date, in terms of years, either for the first appearance of Man or for any event outside the written record. We may draw cheques upon "The Bank of Force" as well as on "The Bank of Time."

Two of my predecessors in this chair, Dr. Woodward and Professor Judd, have dealt with the position of our science in relation to Biology and Mineralogy. Professor Phillips in 1864 pointed out that the later ages in Geology and the earlier ages of mankind were fairly united together in one large field of inquiry. In these remarks I have set myself the task of examining that side of our science which looks towards History. My conception of the aim and results of Geology is, that it should present a universal history of the various phases through which the earth and its inhabitants have passed in the various periods, until ultimately the story of the earth, and how it came to be what it is, is merged in the story of Man and his works in the written records. Whatever the future of Geology may be, it certainly does not seem likely to suffer in the struggle for existence in the scientific renascence of the nineteenth century.

III.—The Relations of the Great Oolite to the Forest Marble and Fuller's-earth in the South-west of England. By Horace B. Woodward, F.G.S., of the Geological Survey of England and Wales.

[Communicated by permission of the Director-General of the Geological Survey.]

THE southerly attenuation of the Great Oolite, and its absence in Dorsetshire, have been generally attributed to lateral changes in the strata—it being considered that the Great Oolite is mainly replaced by Forest Marble (which has been stated to increase in thickness southwards), and perhaps in part by the Fuller's-earth.

In Gloucestershire the Great Oolite and Forest Marble are so interblended that there is no real line of demarcation. At Bradford-on-Avon this is not the case: the surface of the Great Oolite, with its clusters of *Apiocrinus*, indicates a pause in deposition, and we have locally a good line of division between this formation and the Bradford Clay, which is a subordinate portion of the Forest Marble. Southwards the Bradford Clay horizon extends to the Dorsetshire coast, but the Great Oolite is no longer found, and we see no evidence of the Crinoid growth *in situ*. The estimated thickness of the Forest Marble in Dorsetshire has been much exaggerated, and the evidence

furnished by the persistence of the Bradford Clay is opposed to the view that the Great Oolite is replaced in any way by the Forest Marble.

In Oxfordshire and Gloucestershire the Great Oolite and the Stonesfield Slate merge downwards into the Fuller's-earth with no marked stratigraphical division, and this is the case as far as Lansdown, near Bath. Northwards the Fuller's-earth is much attenuated, and near Chipping Norton it rests on a higher stage of the Inferior Oolite than we find in the Cotteswold Hills, as if in the former area the conditions attending the deposition of Inferior Oolite lingered longer. Rarely do we find any interblending of Inferior Oolite and Fuller's-earth; indeed, we sometimes find indications of local pauses in deposition, marked by annelide burrows, etc. So that on stratigraphical grounds the Fuller's-earth is more intimately connected with the Great Oolite than with the Inferior Oolite.

In Dorsetshire the Fuller's-earth series attains its greatest development in this country, and is separable into Upper and Lower clayey divisions, with an intermediate bed of Fuller's-earth Rock. These divisions may be traced northwards to Lansdown and Slaughterford, near Bath, where the Fuller's-earth Rock is present in an attenuated form, and where the Upper Fuller's-earth merges into the base of the Great Oolite.

It is therefore clear that the mass of the Great Oolite is not represented in the Fuller's-earth series of Dorsetshire, although its lower beds may be partially replaced by the Upper Fuller's-earth. The mass of the Great Oolite, therefore, either wedges out abruptly south of Bradford-on-Avon, or has been to some extent denuded. On the whole, it appears probable that the Great Oolite has been denuded—the erosion being local and contemporaneous so far as the Great Oolite series is concerned. The structure of the Forest Marble, with its clay-galls, its current-bedded limestones made up of broken shells and oolitic grains (the latter sometimes in a sandy matrix), favours the notion that it may have been largely derived from previous accumulations; and this opinion was suggested by Dr. Sorby from a microscopical study of some of the beds.

The organic remains of the Fuller's-earth include many species common to the Inferior Oolite and many common to the Great Oolite. Of seventy-two species, obtained during the course of the Geological Survey, fifty-eight are known also in the Great Oolite and forty-two in the Inferior Oolite, a number being common to the two formations. The palæontological evidence therefore coincides with the stratigraphical, that the Fuller's-earth on the whole is more intimately connected with the Great Oolite than with the Inferior Oolite. For convenience of classification it should therefore be placed with the Great Oolite series.

IV.—Note on the Portland Sands of Swindon and Elsewhere.

By Horace B. Woodward, F.G.S., of the Geological Survey of England and Wales.

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ATTENTION was drawn to some fresh sections at Swindon, and these confirmed the sequence made out by Prof. J. F. Blake from somewhat scattered data. The sandy beds that yield the Swindon Stone were originally grouped as "Portland Sands," but they clearly belong to the Portland Stone division, as pointed out by Mr. Blake. The basement-bed here and at Aylesbury consists of a conglomeratic band containing lydites, a few quartz pebbles, and some derived fossils. The true Portland Sands occur below, and are about 60 feet thick. The sequence is as follows:—

		Feet.
Portland Stone, with lydite bed at base and in upper part of clay beneath.		
Portland Sands.	3. Blue and brown clay	19
	2. Sandy calcareous rock. Oyster-bed with small acuminate oyster	8
	1. Greenish and yellowish sands with huge concretionary masses of calcareous sandstone. The sands merge downwards into	30 to 40
Kimeridge Clay.		

Comparing the sequence with that at Aylesbury, worked out by Mr. Hudleston, we find the Portland Stone with lydite bed at base, resting on the Hartwell Clay. This clay, like the Blue and Brown clay (No. 3) at Swindon, was originally taken to be Kimeridge Clay, but the former has been shown to be on the horizon of the Middle Portlandian of French geologists, and there is no doubt, on stratigraphical and palæontological grounds, that the clays of Swindon and Hartwell are on the same approximate horizon, and that both belong to the Portland Sands. We have not clear evidence of the sequence beneath the Hartwell Clay at Aylesbury; but a deep well at Stone, in that neighbourhood, showed the presence beneath the Portland Stone of Blue clay, Limestone, Dark sand, and then Blue clay again—this last-named bed being, no doubt, the true Kimeridge Clay, although detailed measurements are wanting.

Doubtless there is some inconvenience in a term like Portland Sands, when it includes prominent beds of clay like those of Swindon and Hartwell, and when the Portland Stone of Swindon is so largely represented by sand. We might employ the terms Upper and Lower Portlandian, were it not that on the Continent a threefold division has been adopted, and the Lower Portlandian embraces beds that in this country cannot be separated from the Kimeridge Clay. The Middle Portlandian, as before mentioned, represents our Portland Sands and Hartwell Clay; and Professor Blake has applied the term Bolonian to these Middle and Lower Portlandian beds. On stratigraphical grounds it does not appear possible for us to adopt this term, and on the whole the following grouping appears best adapted for the English strata:—

Upper Portland Beds—Portland, Tisbury and Swindon Stone.
Lower Portland Beds—Portland Sands and Hartwell Clay.

It is true that at Swindon and Hartwell the Lower Portland Beds are more intimately connected, on stratigraphical grounds, with the Kimeridge Clay than with the Upper Portland Beds; but this is not the case on the Dorsetshire coast, where no conglomeratic band has been met with at the base of the Portland Stone.

V.—Further Note on the Midford Sands.[1] By Horace B. Woodward, F.G.S., of the Geological Survey of England and Wales.

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THE term Midford Sands, introduced in 1871 by Professor Phillips, has been accepted by many geologists because it avoided the confusion that had arisen from the use by some authorities of the term Inferior Oolite Sands, and by others of Upper Lias Sands.

At Midford the upper portion of the Inferior Oolite (zone of *Ammonites Parkinsoni*) rests directly on the Sands, whereas in other parts of Somersetshire, in Dorsetshire and Gloucestershire, the lower portion of the Inferior Oolite (comprising the zones of *A. Humphriesianus and A. Murchisonæ*) is present above the Sands. In the absence of palæontological evidence, it has been questioned whether the Midford Sands are really equivalent to the Sands in other parts of the south-west of England. Hence other local names, *e.g.* the Yeovil and Bridport Sands, and the Cotteswold Sands, have been introduced.

Regarding the zone of *Ammonites opalinus* and the Gloucestershire Cephalopoda-bed as a portion of the Cotteswold Sands, there is no doubt about their correlation with the Sands of Bridport and Yeovil. Two species of *Ammonites* (*A. striatulus* and *A. aalensis*) have been obtained by the Rev. H. H. Winwood from the Midford Sands. The latter of these species was recorded by myself, on the authority of Mr. Etheridge, in 1876, but its occurrence has been overlooked. More recently I have seen in the William-Smith Collection in the British Museum, an *Ammonite* from the Coal-canal at Midford; and this has been identified by Mr. Etheridge and Mr. R. B. Newton, as very near to, if not identical with *A. Levesquei*, a species recorded by Dr. Lycett from the Gloucestershire Cephalopoda Bed. These species show that the Midford Sands belong to the same general horizon as the Sands of Gloucestershire and Dorsetshire, so that there is no adequate reason for discarding the name Midford Sands. If the beds near Bath have not proved so fossiliferous as those in other localities, there is no reason why they should remain so; for in Dorsetshire there are many sections where the beds appear barren, in close proximity with other exposures that yield an abundant fauna.

[1] A previous Note on the Midford Sands was published in the Geological Magazine, 1872, p. 513.

VI.—On *Bucklandium diluvii*, König, a Siluroid Fish from the London Clay of Sheppey. By A. Smith Woodward, F.G.S.

IN his well-known 'Icones Fossilium Sectiles,' pl. viii. No. 91, König figures a remarkable fossil from the London Clay of Sheppey, which is mentioned in the text as not certainly determinable, but generally regarded, by the anatomists who have examined it, as pertaining to some type of Lizard. This specimen is preserved in the British Museum, and the author has determined that it is truly the imperfect head and pectoral arch of a Siluroid. The roof of the skull is preserved almost as far forwards as the middle of the frontals; the pectoral arch is in position, though slightly bent backwards; and the mass of anchylosed anterior vertebræ, with the basioccipital, is displaced downwards and thrown beneath the clavicles. All the bones are remarkably strong, and the exposed surfaces are ornamented with large tubercles. The head must have been originally somewhat deeper than broad, and the roof exhibits no flattening, but is strongly arched from side to side. Posteriorly, the supraoccipital projects in the usual manner, probably to meet a dermal plate upon the nape; and the post-temporal element seems to be merged with the bones of the postero-lateral angles of the cranium. It is impossible to determine the family-position of the genus in the usual manner, but the skulls of the West African *Auchenoglanis* and *Synodontis* appear to approach the fossil most closely. The provisional name of *Bucklandium diluvii* may be retained; and the fish is interesting as being the earliest undoubted Siluroid hitherto discovered.

VII.—A Comparison of the Cretaceous Fish-fauna of Mount Lebanon with that of the English Chalk. By A. Smith Woodward, F.G.S., F.Z.S.

NO detailed comparison having hitherto been instituted between the Cretaceous fish-fauna of Mount Lebanon and that of the English Chalk, which belongs to a well-determined horizon, the author has undertaken a general survey of the genera, with the result that the two faunas are proved to have more forms in common than hitherto supposed. The Selachian fishes are scarcely comparable, *Notidanus* and *Squatina* being the only genera as yet recognized in the two formations; and, on the whole, those of Mount Lebanon exhibit the most modern facies, all traces of Hybodont Sharks and of *Ptychodus* being wanting. Chimæroids are unknown at Mount Lebanon, but abundantly met with in the English Chalk. Among Ganoids there are representatives of the Pycnodonts both in the Lebanon (*Palæobalistum, Coccodus, Xenopholis*) and in England (*Cœlodus*), but no identical genera can yet be recognized. Rhombic-scaled Ganoids are rare in the English Chalk (*Lophiostomus, Neorhombolepis*), and unknown in Mount Lebanon; traces of Acipenseroids also occur in the former, but have not been discovered in the latter; and at least one Crossopterygian genus occurs plentifully in England (*Macropoma*), while no uncertain remains have been

detected in the Syrian beds. *Belonostomus*, however, is common to the two formations, one species having been described from Mount Lebanon under the name of *Rhinellus laniatus*.

Of Physostomous Teleosteans, the great early families represented in the Chalk of England and the Upper Cretaceous of North America by *Portheus*, *Ichthyodectes*, *Protosphyræna* and *Pachyrhizodus*, are quite unknown in the deposits of Mount Lebanon; but in the latter locality *Enchodus* is abundant, having been described under the synonym of *Eurygnathus*, and this is accompanied by a closely-allied genus, *Eurypholis*, only differing in the possession of a few dermal scutes. The English *Pomognathus* may also be regarded as represented at Mount Lebanon, for the so-called *Phylactocephalus* merely differs in the presence of extremely delicate minute scales, which would not be preserved in a matrix of the nature of the Chalk; and *Aspidopleurus* (Mount Lebanon) possesses scutes indistinguishable from the detached examples long known in the English Chalk under the name of *Prionolepis*. *Dercetis*, also, is met with abundantly in the Syrian beds, being described under the synonym of *Leptotrachelus*. Among Elopine Clupeoids, some undescribed forms occur in the English Chalk, and one from Mount Lebanon has been erroneously assigned to the genus *Clupea* (*C. Lewisii*); and the supposed Salmonoid, *Osmeroides*, is common to the two formations, though inferior in size at the last-named locality. In the Syrian deposits, however, there are many more specialized Physostomi, such as *Cheirothrix*, *Spaniodon*, *Opistopteryx*, *Rhinellus*, *Scombroclupea*, *Diplomystus*, and *Clupea*, not represented among English Chalk fossils. Among Physoclystous Teleosteans but few genera are common to the two formations under comparison. *Hoplopteryx*, with perhaps *Beryx*, represents the Berycidæ in both localities; but only a single imperfect specimen from the English Chalk can yet be assigned to any higher type, namely, *Platax* (?) *nuchalis*. At Mount Lebanon more specialized Physoclysti are numerous, as *Platax*, *Imogaster* and *Pycnosterinx*; although to the latter have been erroneously assigned certain extraneous forms, including at least one well-marked Berycoid, the so-called *Pycnosterinx Lewisii*.

The conclusion is thus arrived at, that in those respects in which the Lebanon fish-fauna differs from that of the English Chalk, it exhibits greater specialization. Considered alone, therefore, it is distinctly of a more modern type than the latter, although the beds in which it occurs are regarded, from other evidence, as being of Senonian or even Turonian age.

VIII.—On the Recent Volcanic Structure of the Azorean Archipelago. By Osbert H. Howarth.

THE object of the author's notes upon the relation of the Azorean group to the other islands of the West Atlantic is to indicate a line of inquiry by which some approximation may be made to the intervals separating the great eruptive changes; and determining any modifications in the type of flora during that important succes-

sion of volcanic products, which has been evolved since the Upper Miocene period assigned to the islands generally. A field for such inquiry seems to be offered by the present phase of action in the Furnas district, in the eastern centre of St. Michael's, where existing activity is associated with some of the oldest formations in the series. The author has traced in that valley a series of beds of vegetable origin dating back from the most recent changes, immediately connected with the present boiling-spring area, to a period antecedent to the formation of the Furnas Valley itself. The intermediate intervals of repose are now represented by peaty beds and subaqueous vegetable deposits, interstratified with the successive lava streams, tuffs, and pumice beds of various dates, within and prior to the historical period. From the more recent of these, buried trunks and branches have been obtained which represent the intervals of recent eruptions; while in one of the older tuffs, underlying nearly the whole series at that portion of the islands, a tree (probably an *Erica*) has been found, presumably *in situ*, and offering possibilities of a subjacent soil for examination, which would be contemporaneous with the earliest vegetation of the island.

IX.—THE VOLCANOES OF THE TWO SICILIES. By TEMPEST ANDERSON, M.D., B.Sc.

THE author has recently visited the volcanoes of Naples, the Lipari Islands and Sicily, including Vesuvius, Stromboli, Vulcano and Ætna, and taken photographs of their craters and some of their lava streams, and other most important parts, in order to obtain a record of their present condition which may be available for comparison in case of future eruptions. Some of these photographs were shown as projections on a screen by means of a lime-light lantern.

REVIEWS.

THE BUILDING OF THE BRITISH ISLES: A STUDY IN GEOGRAPHICAL EVOLUTION. By A. J. JUKES-BROWNE, B.A., F.G.S. Sm. 8vo. pp. 335, with Maps and Woodcuts. (George Bell & Sons, 1888.)

ONLY a few years have elapsed since the late John Richard Green, combining physical geography, archæology, and history in the most happy manner, presented his fellow-countrymen with that admirable story in the development of their race, entitled "The Making of England." We are now presented with an equally interesting volume of physical history, and somewhat wider geographical scope, in which is told the story, how and during what geological periods the British Isles were built. Just as the modern English are a remarkable mixture of many races, so are the British Isles, as every geologist knows, a most remarkable epitome of the physical history of the Earth's crust, our limited territory being in fact like Jacob's coat in respect of the variety of the pieces which go to make it up.

Thus the story of the "Building of the British Isles" involves to a considerable extent the history of most of the geological formations. To write a book of this kind successfully requires peculiar qualifications, and certainly no one is entitled to attempt the task who does not possess a tolerably intimate acquaintance with the geology of Western Europe, a fair share of the imaginative faculty and good literary abilities. To these it will be generally conceded that the author may fairly lay claim, and we must now proceed to consider what use he has made of them in the work before us.

The study of geographical evolution has had many votaries, both in this and in other countries. The early efforts of Godwin-Austen in this direction have been singularly confirmed by the deep borings made of late years in the Eastern and Midland Counties. Indeed, it is the frequency with which the Neozoic rocks have been probed in so many localities—mostly in search of water, more rarely to find coal—which enables the modern geologist to lay down with tolerable accuracy the suberranean surface of the Palæozoic rocks. We have a good summary of these results, as applied to a certain line of country, in the diagram-section (p. 115), from the valley of the Severn to the valley of the Lea. [N.B.—A more clearly defined sea-level line would improve this section.] The information thus acquired provides the means by which it is possible to reconstruct the Mesozoic geography of a large part of England with a tolerable degree of probability. There is just one terrible factor in the account which must present itself to every one who attempts geographical restoration from geological data, viz. the imperfection of the geological record. This the author admits with a candour which is in good keeping with the general sobriety of the book. "In some instances," he says, "the facts which are known suggest different inferences to different minds, and there are several cases in which different views are held with regard to a certain area having been above or below water during a certain period. In such cases I have carefully examined the different views which have been taken by those who have written on the subject, before selecting that which appeared to be the most probable interpretation of the facts."

The plan of the book is as follows. He gives a summary of the stratigraphical evidence of each period, followed by a geographical restoration, which is further exemplified by a map, in which the present outline of the British Isles is indicated by a red line, whilst horizontal blue lines represent the area which is supposed to have been covered by water during the successive periods. There are fifteen of such maps, plates xii. xiii. and xiv. being drawn on a smaller scale so as to include Iceland and parts of the west coast of the Continent and Norway. The following periods are recognized:—The Cambrian, Ordovician, Silurian, Old Red or Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Hantonian (Eocene and Oligocene), Icenian I. (Miocene and Pliocene), Icenian II. (Pleistocene). Then follows a summary of the geographical evolution of the British Isles, and in the last chapter he discusses the theory of the permanence of oceans and continents.

"At present," he admits, "that the maps of early Palæozoic geographies are only pictorial representations of the ideal views which are suggested to our minds by the inferences obtained from the study of a few small and disconnected areas." This is perhaps a somewhat off-hand way of describing the earlier Palæozoics of our country, but he is perfectly right in attaching no particular value to such restorations. Pre-Carboniferous geography is very much a matter of fancy, and we bear in mind the old saying "*De gustibus non est disputandum.*" One feature in these early speculations seems to enforce itself, viz. the unwillingness of the west part of Anglesey to go under water. Both in the Arenig and Llandovery epochs this obstinate little island refused to be entirely submerged. The same was the case in Lower Devonian times. Even during the epoch of the Carboniferous Limestone the north-west corner is represented as being still unsubmerged. Surely it is Anglesey, and not Kent, which should inscribe "*invicta*" on her escutcheon. This was connected with a block of very old land on the site of St. George's Channel, including a strip of Eastern Ireland, which seems to have been a sort of "*omphalos*" of the British Islands. The central portions of this block are represented as being land in every one of the fifteen maps except the last, though we presume that the author regards it as having been covered during the great submergence of the Chalk epoch.

When we try to restore the geography of the Carboniferous period, there is already something more definite to formulate, and "we can point to districts which seem to be the worn-down remnants of Carboniferous land tracts." No one can dispute this, but is there such good proof that at this period "there was more land than water where the Atlantic now rolls"? This is rather a strong statement for so cautious and conscientious a writer as Mr. Jukes-Browne. He regards the "continent" to which the Palæozoic nucleus of our islands was subsidiary as lying to the north and north-west of the British area. This "Continent" can be no other than the hypothetical Atlantis, a creation of the period when oceanography was in its infancy. He perceives the unfavourable bearing of this assumption upon the general principles of physical evolution, and explains that probably the seas and continents of the Palæozoic world had an evolutionary history of their own, which culminated in the geographical conditions of the Carboniferous period. His views are more fully set forth in the last chapter, where he discusses "the theory of the permanence of Continents and Oceans." No doubt he will have many opponents, and it is evident that, henceforth, there will be two schools of geographical Evolution, and that the results will vary materially according to which of these two schools an author may happen to belong.

Reverting once more to the main subject of the book, every geologist is aware that, however much of the older rock material had been roughly fashioned before the upheaval of the Carboniferous deposits, yet the building of the British Isles only commenced in earnest during the interval which succeeded the close of this period. Then were traced the main outlines of the skeleton of Palæozoic

rocks upon whose stony flanks and platforms the softer Neozoic deposits were to be thrown down, these latter also to be hardened, raised up and sculptured in their turn. The Permian deposits may perhaps help to throw some light on the latter part of this revolutionary interval, since their fauna is linked with that of the preceding age, although their physical relations to the older rocks are of the most discordant character.

We have now arrived at a time in geographical restoration when it is possible to speculate with some chance of being correct. Plate v. introduces us to the geography of the Permian period. The area is mostly land: an impounded water-space lies to the west of the Pennine chain, whilst on the east the Magnesian Limestone Sea is extended indefinitely across the central portion of the North Sea area, as though it might possibly still communicate with an ocean. The next plate represents the period of the Keuper, the continental phase still predominating in this area. A lake of curious shape extends from the Gulf of Normandy across the west centre of England until it is split by the Pennine mass into a north-eastern and a north-western area. This no doubt would be highly saline. Subsidiary basins, presumably of fresh water, occupy a southerly prolongation of the Minch and the Moray Firth. These two maps represent the great period of chemical precipitation in our area.

By the time of the Lias and Inferior Oolite the general lowering of the land had enlarged this water-space, which now appears as an arm of the sea with marine connections across the Paris basin, but retaining in no small degree the shape of the old Triassic lake. There are even rivers, one of which flows in from the west at a point in the Bristol Channel between the coasts of Devon and Wales. Another river flows into an estuary opposite Cleveland, and a third debouches a long way outside the Moray Firth. These two rivers are supposed to drain the continent to the north-east; the embouchure in each case is within the area of what is now the North Sea, and consequently not accessible to close examination. Within the limits of the map there is a considerable preponderance of land. Premising that nearly the whole of the North Sea and the North Atlantic is represented as being land, the following blocks may be distinguished in addition: (1) the Highlands north of the Great Glen; (2) the bulk of Scotland with its continuations in the Pennine chain and towards the Isle of Man; (3) nearly the whole of Ireland; (4) Wales; (5) the Damnonian Peninsula; (6) the Palæozoics of Kent and East Anglia. It was these lands, and more especially the recently exposed Carboniferous, which provided the bulk of the Jurassic sediments. The view that the Jurassic clays were largely derived from the denudation of Coal-measure shales found an able exponent, some years ago, in Prof. Blake. It is doubtful if much was derived from the hypothetical East Anglian land.

Mr. Jukes-Browne considers that, allowing for oscillations at various times and in different places, the area continued to sink throughout the Jurassic period, and he does not hold the opinion, so

generally adopted, that the Oxfordian epoch represents the period of maximum depression, although he allows that a large part of the eastern land was submerged during the formation of the Oxford clay. "The episode of the Corallian beds," he says, "marks a time when from some cause the deposition of mud ceased over certain parts of the sea-bottom, and the water became clear enough for the growth of coral reefs." He concludes that this represents a pause in the general subsidence. Such an explanation will only suit some districts, because the Corallian limestones, etc., have their argillaceous equivalents over considerable areas. We are inclined to think that the Oxfordian beds do, on the whole, represent the most extensive and regular depression of Jurassic time in our own and neighbouring areas, that the Corallian beds indicate, as the author says, a pause, but one of irregular distribution, and that the Kimmeridge Clay was deposited in an oscillating area—a supposition which can alone account for the extraordinary variation in its thickness and character within short distances.

These oscillations at length resulted in the restriction of the Jurassic water-spaces, such as must have occurred during the Portlandian epoch. This geography is represented in plate viii. The Portlandian Sea is open towards the Paris basin, and occupies only a portion of the South of England. A strip of water on the coast of Lincolnshire and East Yorkshire has an undefined connection with a gulf which points towards Germany, and there is the usual water-space to the south of the Isle of Man—admitted to be hypothetical. It is interesting to note that throughout the first half of Mesozoic time, dating from the Permian to the Portlandian, whilst the Atlantic is completely ignored, whilst of the North Sea and the English Channel there is not the slightest trace, yet the shallow Irish Sea is always represented as having been submerged. Certainly a boring in this area, if it were possible, should produce most interesting results. Permian, Triassic, Liassic, and Oolitic rocks, even to the Portlandian, ought there to be found in undisturbed sequence.

The remaining periods must be considered briefly. Omitting the stage of the Purbeck-Wealden, we find, when marine deposits once more take place, the two principal water-spaces of the Portlandian epoch, somewhat modified, are now connected by narrow straits in the East Midlands. This arrangement represents the Aptien (Lower Greensand) stage of the Lower Cretaceous (plate ix.). All else is land. Even the bed of the Irish Sea is at length brought up to day, and might thus lose some of its earlier Mesozoic deposits. But, since coming events cast their shadows before, a dubious outline of the Atlantic for the first time appears off the north-west coast of Ireland. This scene may be taken to represent the last stage of Mesozoic geography before the great submergence which ultimately brought the waters of the Chalk Sea over the area of the British Isles. The author does not venture to portray the great consummation, but plate x. represents the geography of the period when the basal sediments of the Chalk, *e.g.* Gault, Upper Greensand, etc., were creeping over England. The laying down of the probable

coast-line at this juncture is an interesting piece of work, and for much original information on this point we are indebted to the author himself, and to his friend, Mr. Hill. Parallel to this coast-line, but still separated from it by some 200 miles of the unsubmerged Britannic block, is the shadowy Atlantic ready to unite with the eastern sea. Even at this juncture nothing but land is represented to the north of Scotland and the south of Ireland.

Recalling the general views of the author as to the relations of land and sea within the area treated from the beginning of Mesozoic time to the eve of its closing scene, we are somewhat struck by the limited amount of water-space. The curious shape of the Keuperian reservoir, with its fresh-water adjuncts in the north-east and north-west of Scotland, is copied with singular fidelity by the seas of the Lias and Inferior Oolite, the only access to any ocean being a problematical one through the Paris basin. It is difficult to believe that such a thoroughly marine formation as the Lias was deposited in waters so stale as these must have been. We observe, too, that the author considers such a minor accident of the Earth's crust as the Great Caledonian Glen to have been already in existence, and yet he persists in ignoring the Atlantic basin, the eastern edge of which is quite as likely to have been a permanent feature. Moreover, we do not feel quite convinced of the existence of such a great mass of land to the north during Mesozoic times as is represented in all the maps. It is to be hoped that the Oxfordian seas were allowed a little more latitude in this direction.

Tertiary Geographies.—During the Lower Eocene period the Britannic block is represented as being all land to the west of a line between the Wash and Bridport Bay: the London Clay sea covers the rest. During Oligocene, and presumably during Miocene times, it merely forms part of a continental mass which extends from the Bay of Biscay to the Scandinavian Highlands. In the course of this lengthened exposure the carving of the British Isles must have made progress: the escarpments of the Secondary rocks would be roughly outlined, and the older rocks again touched up. "It is possible that some of the geological features of western and central England were initiated at this time" (p. 247). But Mr. Jukes-Browne considers that we cannot use the modern physical geography of the country as affording much assistance in the restoration even of early Pliocene geography, though he thinks that the German Ocean may have been initiated "in the latter part of what we call Pliocene time."

"That the close of the Pliocene epoch found the main physical features of England fully developed, and the Mesozoic escarpments occupying their present positions, we know from the relations of the Pleistocene (Glacial) deposits to these features." The wonderful change which had taken place during the latter part of the Pliocene is depicted in pl. xiii. As if by magic nearly everything is in its place. The German Ocean is an accomplished fact. Rivers drain the valleys which prefigure the English and St. George's Channels, and at length the Atlantic is permitted to mingle its waters with

those of the deep Norwegian basin. The river-system is, on the whole, similar to that which now exists, and we may fairly infer that the building of the British Isles was completed. All we can say is, that there must have been good workmen in later Pliocene times; for if these views are correct, considerably more than half the physical features of the British Isles, both geographical and hydrographical, date from this limited interval of geologic time.

In dealing with the final or Pleistocene stage, its abnormal climate, its submergences, and all the other enigmas of the Great Ice Age, the author avoids the extreme theories which find so much favour in some quarters. He allows that "the uncertainty which exists with regard to the real succession, and to the precise mode of formation of these Glacial deposits, makes it unsafe to attempt a geographical restoration of any of the several phases of the Glacial epoch." He prefers to select for illustration the period in Pleistocene time when the rigour of the Ice Age had moderated, and when the British region had emerged from the waters of the Glacial Sea. The bed of the German Ocean is now so filled with *débris* that "the upheaval necessary to convert this sea into land after the Glacial period was 100 fathoms less than would have been required to effect the same result in later Pliocene time." An extension of the Rhine meanders through the great plain, to which the rivers of Eastern England are tributary. This represents the epoch when the coast-line of Western Europe coincided with the 80 fm. contour. Subsequently the water gains on the land, these low-lying tracts are destroyed, and our narrow seas are being cleaned out. The last great geographical touch was given when the tidal waters, assisted perhaps by depression, eat their way across the low water-shed of two river-valleys which is now marked by the Straits of Dover.

We have followed Mr. Jukes-Browne with much pleasure through this very interesting study in geographical evolution, and can strongly recommend it to the attention of all geologists and physical geographers. In a case of this sort it is far easier to criticize than to construct, and no doubt each specialist could find something to suggest in every stage of the process from the earliest Palæozoics to the latest Pleistocene times. Many points, also, in ancient geographies must for ever remain mere matters of opinion. What is especially to be commended in this book is its freedom from any extravagant ideas: the author has taken for his motto, *in medio tutissimus ibis*, and in this spirit has acted throughout.—W. H. H.

NOTE ON A GLACIAL BED IN BEDFORDSHIRE.

SIR,—The Lower Greensand forms a well-marked escarpment running parallel to that of the Chalk through Bedfordshire, and overlooking the flats consisting of Oxford and possibly Kimeridge Clay. About a mile from Ampthill in the direction of the ruined mansion at Houghton, quite on the edge of the escarpment, and facing the

north-west, there is a large pit worked for sand and gravel, which has apparently escaped attention, or at least description. The beds are obviously Glacial, and apparently coeval with the Boulder-clay, but the boulders and pebbles are cemented with greensand, and not with clay. The stratification is distorted, and discontinuous. The greatest depth of the section is about 35 feet, and the beds extend further beneath. Beginning from below, the layers are in one part as follows: loam, conglomerate of boulders, clay, conglomerate, sand, pebbles and half-rounded flints, sand, conglomerate, sandy subsoil; the thickness of each layer being three or four feet. The pebbles and fossils are of all ages, but flint, chalk boulders, and hard iron sandstone predominate. There are also fragments of lignite; Ammonites from the Oolite; Granite, and Igneous rocks. It is just possible that the beds have been deposited under the combined action of ice and rivers, but the beds in no way resemble the river-gravels of the Ouse. A layer of sand 3 or 4 feet thick, and about 25 feet in length, is absolutely free from pebbles, and is of a fine white texture, similar to that used for commercial purposes, and quarried from the Lower Greensand in many places. It looks as though it had been pushed or transported bodily, without any disturbance from the Greensand.

The conglomerate is extremely hard, and fractures occur across the contained pebbles like Hertfordshire pudding-stone. A search for flint implements proved, as was expected, futile.

This section thoroughly deserves a visit, and I should be glad to learn the opinion of geologists about its age and probable method of formation.

P.S.—Mr. Cameron, of H.M. Geological Survey, is of opinion that these beds are Middle Glacial.

A. S. Eve.

Marlborough College.

DISCOVERY OF A CIRRIPEDE IN CANADIAN PALÆOZOIC ROCKS.

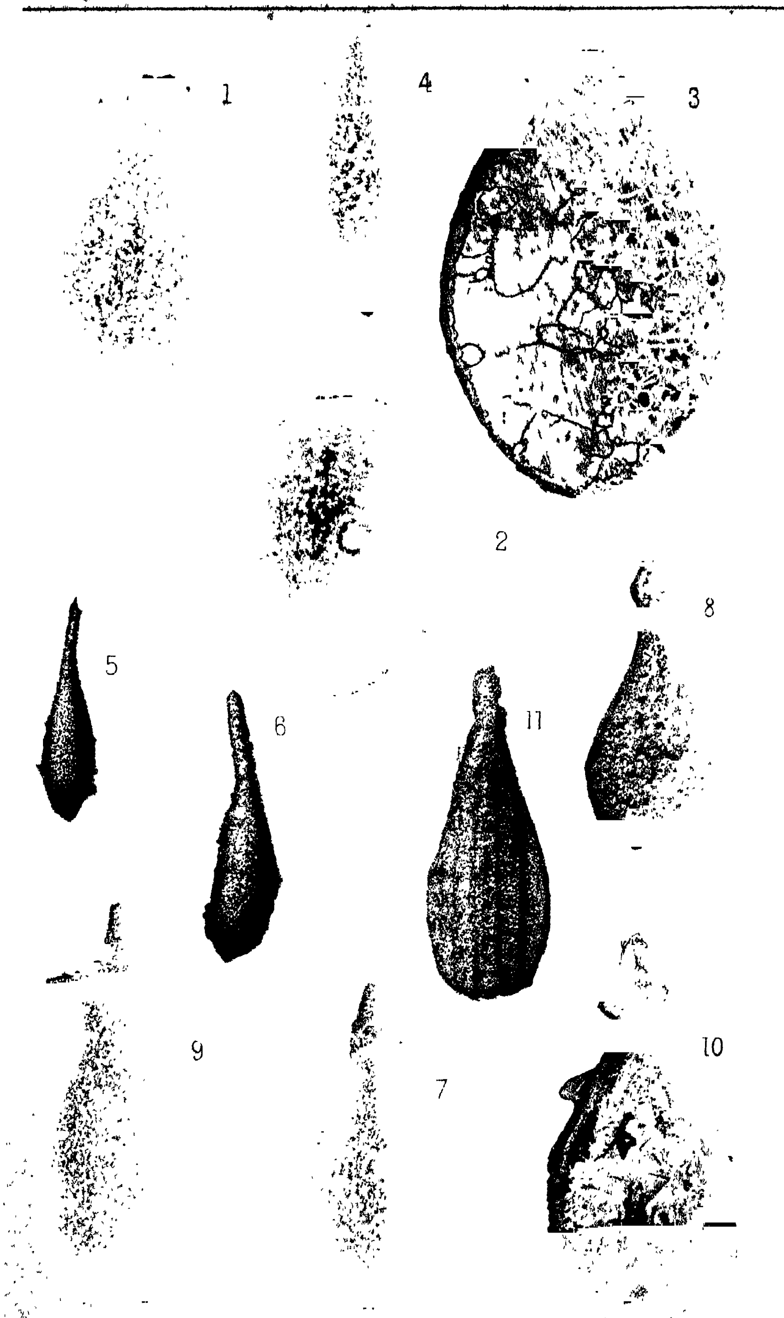
Sir,—I have just received a communication from my friend Mr. Henry M. Ami, M.A., F.G.S., of the Geological Survey of Canada, dated Ottawa, 23rd August, 1888, in which he makes the following interesting announcement in a postscript:—

"Last Saturday afternoon, whilst collecting in the 'Siphonotreta' band [lower part of Utica Formation = Bala Limestone Group, in part] along the Rideau River—near the rifle range—I had the good fortune to come across what appears to be a fossil Cirripede, allied to *Turrilepas*. The group to which these ancient barnacles belong lies still in much obscurity; Darwin, Woodward, Lindström, Hall, and Clarke have written on them. I think this is the first time we have found any in Canada in Palæozoic rocks."

I have only to add that I expect shortly to receive the specimen from Mr. Ami for description.

Arthur H. Foord.

66, Edith Road, West Kensington, W.



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ORIGINAL ARTICLES.

I.—Note on some Silurian Lagenæ.

By Henry B. Brady, LL.D., F.R.S.

(PLATE XIII.)

We are in possession of so little accurate information concerning Foraminifera of pre-Carboniferous age, that any contribution to the knowledge of the subject, however insignificant it may of itself appear, has a very distinct value. The only notices of pre-Carboniferous examples of the genus *Lagena* hitherto published occur in a provisional list of Microzoa drawn up by Professor T. Rupert Jones, F.R.S., and appended to a paper by Mr. J. Smith of Kilwinning, "On a Collection of Bivalved Entomostraca and other Microzoa from the Upper-Silurian Strata of the Shropshire District," in the Geological Magazine for February, 1881; and in a brief allusion to the same specimens in the "Report on the Challenger Foraminifera" (p. 449, etc.), but in neither case is the notice accompanied by any details.

Recently, through the kindness of my friend Prof. T. Rupert Jones, I have had the opportunity of examining a number of specimens, similar in many respects to those just referred to, collected by the late Dr. H. B. Holl in a neighbouring county and from beds approximately of the same age, and have had permission to use them in any way needful for their elucidation. Mr. J. Smith has also been good enough to lend me his original mountings with the same liberty as to their employment. I have thus been enabled to make a tolerably complete examination of the whole, the results of which are embodied in the following notes.

Prof. T. R. Jones's collection consisted of between forty and fifty specimens, typical examples of which are represented in Figs. 1–4 of the accompanying Plate. They were obtained from the base of the Wenlock Shale and from the shales of that part of the Lower-Wenlock Series known as the Woolhope Limestone · all from the Wych, Malvern.

The specimens exhibit considerable range of contour; some few are nearly globular, but the larger number are pyriform, the inferior end of the test broad and rounded, the upper portion more or less tapering, as shown in Fig. 1. Some of the shells are perceptibly

flattened on two sides, probably the result of pressure, and present an oval instead of a circular transverse section. A few specimens of smaller size (Fig. 4) are more elongate and fusiform, the two ends being drawn out nearly equally and the inferior extremity bluntly pointed. The surface of the fossils is generally rough, owing partly to the corrosion of the test and partly to the adhesion of minute fragments of the matrix. The aperture is simple and circular, often indistinct owing to the nature of the infiltrated material. The specimens vary much in point of size, measuring from $\frac{1}{25}$ to $\frac{1}{12}$ inch (roughly from 1 to 2 millim.) in length, and from $\frac{1}{60}$ to $\frac{1}{18}$ inch (0·42 to 1·4 mm.) in transverse diameter.

None of this set exhibit the long tapering neck which gives to the typical *Lagena lævis* its characteristic flask-like contour. It is true that the neck may have existed; but if so, it is remarkable that it has not in any case been preserved either in the form of external shell or internal cast, inasmuch as it remains uninjured in smaller and more delicate specimens from a not far distant locality. When first examined, it was thought possible, chiefly on account of their size, that some of these little fossils might turn out to be *Polymorphinæ*, as they bear considerable external resemblance to certain species of the "Globuline" section of that genus; but neither on the surface nor in the interior have any traces of septation been discovered. After careful comparison it does not appear that the dimensions of even the larger examples need be a serious objection to their acceptance as *Lagenæ*. It is true that either amongst recent or fossil *Lagenæ*, shells measuring $\frac{1}{20}$ inch (1·2 mm.) are very rare; but the "Challenger" dredgings furnished at least one representative of this genus (*Lagena marginata*), the diameter of which including the wing was just about the same as that of the largest of the Silurian specimens, namely, $\frac{1}{12}$ inch (2 mm.).

That some of the specimens under notice are only casts, and that the others have had the exterior much weathered and corroded, admits of no doubt; nevertheless, thin sections of the smoother more perfect individuals show unmistakable remains of the original test (Fig. 3). Where least altered this is seen to be a tolerably homogeneous wall about $\frac{1}{700}$ inch (0·036 mm.) in thickness. Treated with weak acid both the test and its subcrystalline contents dissolve rapidly, leaving only a faint trace of siliceous residue.

Compared with the foregoing, the specimens collected by Mr. J. Smith, which number about twenty in all, are of exceedingly small dimensions. In point of size they have nothing to distinguish them from average recent examples of the genus. They are mostly of the simple flask-shaped type, with rounded base and long tapering neck (Figs. 6—10), with which we are familiar as *Lagena lævis*. They vary in length from $\frac{1}{90}$ to $\frac{1}{45}$ inch (0·28 to 0·57 mm). A few have the pointed base (Fig. 5) which characterizes the varietal form known as *L. clavata*. They are for the most part casts, and it is difficult to say whether any portion of the original shell-wall remains, though transparent sections (Fig. 10) show in places a more or less distinct external layer, differing in texture from the inner subcrystal-

line mass. One or two of the fossils exhibit traces of exogenous spiral ornament round the neck (Fig. 6), a not uncommon feature of recent *Lagenæ* and *Nodosariæ*. What is more remarkable is the tendency shown in a very large proportion of the specimens to produce a local thickening of the neck in the form of an external rim or collar. Many years ago Dr. Alcock described some similar flask-like *Lagenæ* from the shore-sand of Dog's Bay, Connemara, in the following terms :—"Finely granular in texture, the surface without any raised markings, and at the base of the neck a projecting collar."[1] To these he gave the name *Lagena antiqua*. More recently Dr. Marsson has figured a costate variety with similar collar from the Chalk at Rügen, under a distinct generic name, *Capitellina*.[2] But the fact is that ectosolenian *Lagenæ* of all kinds may be found with exogenous neck-ornament, which may either take the form of a collar, as in the present case, or of a series of rings, a spiral thread, scattered spines, or a number of symmetrically disposed vertical buttresses. Recent specimens exhibiting these and other varieties of neck-ornament are figured in Plates lvii. and lviii. of the Report on the 'Challenger' Foraminifera, and it will be readily seen from them how little importance is to be attached to such features as distinctive zoological characters: nevertheless, it is exceedingly interesting to meet with like morphological conditions amongst the earliest known representatives of the genus. That the ring or collar is seldom quite symmetrical in the fossil specimens under notice, probably depends either on pressure, many of the shells being to all appearance crushed out of shape, or on the unequal weathering of the surface, perhaps on both.

In one or two instances, Fig. 11 is an example, the specimens show the remains of superficial costæ, though considerably obscured by the pressure to which they have been subjected. There need be little hesitation in assigning these to the well-known recent species *Lagena sulcata*.

The localities given with Mr. Smith's series are Lincoln Hill and the railway-cutting at Ironbridge, Dorminton Wood, Benthall Edge, Sedgley, and Woolhope.

From these gatherings we learn that at least four of the varieties of *Lagena* at present living in our seas, namely, *Lagena globosa*, *L. lævis*, *L. clavata*, and *L. sulcata*, have a genealogy reaching back to the Upper-Silurian epoch. Nothing unfortunately can be said as to the probable depth of the deposit in which they have been found, inasmuch as similar forms have been taken in the living condition at almost every depth from the littoral zone down to 2500 fathoms.

I may be permitted just to add that the accompanying Plate has been drawn by Mr. Hollick, with his accustomed accuracy, direct from the specimens.

[1] "Mem. Lit. and Phil. Soc. Manchester," 1868, ser. 3, vol. iii. p. 176, pl. iv. fig. 3.

[2] *Capitellina multistriata*, Marsson, 1878, Mitth. nat. Ver. Neu-Vorpom. u. Rügen, Jahrg. x. p. 123, pl. i. fig. 3.

EXPLANATION OF PLATE XIII.

Figs. 1-3.	*Lagena globosa*, Montagu, sp.	
	1. Lateral aspect; 2. Oral aspect.	Magnified 25 diam.
	3. Longitudinal section	× 35.
Fig. 4.	*Lagena clavata*, D'Orbigny, sp. (?)	× 35.
Fig. 5.	*Lagena clavata*, D'Orbigny, sp.	× 100.
Figs. 6-10.	*Lagena lævis*, Montagu, sp.	
	6. Small specimen with remains of spiral neck-ornament.	× 100.
	7, 8, 9. Specimens with collar encircling the neck.	× 100.
	10. Longitudinal section.	× 100.
Fig. 11.	*Lagena sulcata*, Walker and Jacob.	
	Crushed specimen; lateral aspect.	× 100.

II.—On the Discovery of the Olenellus Fauna in the Lower Cambrian Rocks of Britain.

By Prof. Charles Lapworth, LL.D., F.R.S., F.G.S.

THE brief paper on the "Stratigraphical Succession of the Cambrian Faunas in North America," communicated to *Nature* of Oct. 4, 1888, will have been read by British students of the Geology of the Lower Palæozoic Rocks with especial interest and satisfaction, as it puts an end to a controversy between European and American Geologists, and brings into harmony the sequence and palæontology of the Cambrian faunas on both sides of the Atlantic.

The remarkable fauna of the *Olenellus* or lowest Cambrian zone, originally discovered in America by Dr. Emmons in 1844, was first recognized in Europe by the late Dr. Linnarsson in 1871, in the basal zones of the Cambrian near Lake Mösen in Norway, but its typical genus *Olenellus* was then referred by him to the allied but more recent genus *Paradoxides*. This reference was corrected by Prof. Brögger in 1875; and the various brilliant papers on the Primoidial formations by this author have given the *Olenellus* fauna a marked and peculiar interest. In 1882 Linnarsson next made known the existence of the *Olenellus* fauna in Scania, at the base of the Swedish Cambrian. In 1886 the same fauna was detected by Mickwitz in the Lower Cambrian of Russia (Esthonia), and this Russian fauna has been lately figured and described in detail by Dr. Schmidt of St. Petersburgh. Still more recently (December, 1887) Dr. Holm has signalized the existence of the *Olenellus* fauna in the Cambrian of Lapland, where it was detected by Mörstell in 1885.

Thus the existence of this remarkable fossil group (the oldest well-marked fauna yet recognized by geologists) in the Lower Cambrian Rocks has been already demonstrated in three main regions, viz. (1) in the region of the Rocky Mountains; (2) in the region of North-East America; and (3) in the region drained by the Baltic Sea. But up to the present time, no notice of its presence has been recorded from the British Islands, where the oldest fauna hitherto described is that of the overlying *Paradoxides* zones, or Middle Cambrian formations.

The presence of traces of the *Olenellus* fauna in the West of England has, however, been known to myself for some time. The first recognizable fragments of the characteristic genus *Olenellus*

were detected by me on the flanks of Caer Caradoc in 1885, but they were too imperfect for description. During the summers of 1887 and 1888, Mr. H. Keeping of Cambridge, who has been collecting under my direction the characteristic fossils of the Lower Palæozoic rock-zones of the district, for the Woodwardian Museum, has obtained a sufficiency of fragments to enable us to recognize a large and well-marked species of *Olenellus*. This species possesses characters apparently intermediate between the European form *Olenellus Kjerulfi* (Linnarsson) and the undescribed American form *Olenellus Bröggeri* (Walcott, MS.); but it is so closely allied to the last-named species, that I prefer to await the publication of Walcott's diagnosis of his form before publishing its specific description. I have provisionally named it *Olenellus Callavei*, after Dr. Charles Callaway, F.G.S., who was the first to demonstrate the presence of fossiliferous Cambrian rocks in this Shropshire district, and to collect Cambrian fossils from the special strata under notice.

This lower Cambrian or *Olenellus* formation of the Shropshire area consists of two main members, viz. the basal Quartzite of Lawrence Hill and Caer Caradoc, and an overlying green sandstone, the Comley Sandstone (Hollybush Sandstone of Dr. Callaway). This formation follows unconformably upon the so-called Uriconian rocks of the district, and occurs in many localities, as at Lilleshall, the Wrekin, Caer Caradoc, Cardington, etc. In mapping this formation through the district I find that its fossils are mainly confined to the sandstones and to certain calcareous and phosphatic? beds within them. In addition to *Olenellus* we find in various localities such characteristic Lower Cambrian forms as *Kutorgina*, *Mickwitzia*? and *Acrothele*. The strata of this *Olenellus* zone are succeeded irregularly by (usually faulted against) the Shineton shales of Dr. Callaway, which have long been known to contain in their highest zones an abundant fauna of Lower Tremadoc (Upper Cambrian) age. No trace of the intermediate or *Paradoxides* fauna has yet been detected.

Although this discovery has been well known to my fellow-workers among the Lower Palæozoic Rocks of Britain, I have refrained from placing it upon record, until my identifications could be confirmed by foreign palæontologists familiar with the *Olenellus* fauna abroad. But as the specimens I exhibited at the London meeting of the Geological Congress were unhesitatingly referred to the typical *Olenellus* fauna by Mr. Walcott and Dr. Schmidt, there is no longer any excuse for withholding its publication.

The necessary geological and palæontological details will appear in due course; but as these new facts may, it is hoped, lead geologists in the meantime to a renewed investigation of the strata and fossils of the more ancient formations, it will perhaps be of service to point out that the detection of this lowest Cambrian fauna in beds superior to the Wrekin Quartzite opens out a fresh series of problems in British geology. The presence of *Olenellus* in these beds appears at first sight to fix distinctly the pre-Cambrian age of the so-called Uriconian rocks of the Wrekin and their British equivalents, and even to render the pre-Cambrian age of the Longmyndian a matter

of fair probability. With the Longmynd rocks would possibly go the Torridon Sandstone of N.W. Scotland, the Schists of St. Lo in France, the Sparagmites of Norway, etc. Again, if the Wrekin Quartzite is, as has been more than once suggested, the extension of that of Nuneaton and Durness, then our so-called Upper Cambrian of the Malverns, Central England and N.W. Scotland, may be in reality a greatly attenuated representative of the Cambrian system in general, the British extension of the remarkably attenuated Proterozoic formations of Northern and Western Europe. If so, this attenuated Cambrian may eventually be mapped as patches of an originally, fairly continuous band, ranging from Lapland, through Esthonia, Scania, Norway, Scotland, Central England, France and Spain to the Island of Sardinia. The Sardinian and Durness formations on the extreme S.E. and N.W. points of this line would agree in lithology, age, and fauna, both ranging from the base of the Cambrian up to the lowest zones of the Ordovician. It should carefully be borne in mind, however, that in the present state of our knowledge these suggestions must be regarded simply as constituting a provisional working hypothesis, of service mainly as a stimulus to future discussion, investigation, discovery, and correction.

Grouping together, however, such facts as are already known, and employing Mr. Walcott's nomenclature, we are now able to parallel his American tables by the following European equivalents:—

TABLE I.—*North-Western Europe.*

		NORWAY.	SWEDEN.	ESTHONIA.	LAPLAND.
CAMBRIAN SYSTEM.	Up. Cambrian or Olenus zones.	Dictyonema and Olenus.	Dictyonema and Olenus zones	Dictyonema	Unknown.
	Mid. Cambrian or Paradoxides zones.	Paradoxides zones.	Paradoxides	Unknown	?
	Low. Cambrian or Olenellus zones.	Olenellus zones	Olenellus	Olenellus	Olenellus

TABLE II.—*British Islands.*

		SHROPSHIRE.	ST. DAVIDS.	MERIONETHSHIRE.	CENTRAL ENGLAND.	DURNESS.
CAMBRIAN SYSTEM.	Up. Cambrian or Olenus zones.	Dictyonema and Olenus zones.	Olenus.	Dictyonema and Olenus	Dictyonema and Olenus.	Salterella and Archæocyathus fauna.
	Mid. Cambrian or Paradoxides zones	Unknown	Paradoxides	Paradoxides	Unknown	
	Low. Cambrian or Olenellus zones	Olenellus	Unknown	Unknown	Unknown	

TABLE III.—*Central and South-West Europe.*

		CENTRAL EUROPE.	BELGIUM.	MONTAGNE NOIRE S.E. FRANCE.	SPAIN.	ISLAND OF SARDINIA.
CAMBRIAN SYSTEM.	Up. Cambrian or Olenus zones.	Olenus (Hof)	Dictyo-nema	Olenus	?	Paradoxides and Archæocyathus fauna.
	Mid. Cambrian or Para-doxides zones.	Paradoxides (Bohemia)	Unknown	Paradoxides	Paradoxides	
	Low. Cambrian or Olenellus zones	Unknown	Unknown	Unknown	Unknown	

III.—NOTE ON THE GENUS *ACTINOCERAS*, WITH PARTICULAR REFERENCE TO SPECIMENS IN THE BRITISH MUSEUM, SHOWING THE PERFORATED APEX OF THE SIPHUNCLE.

By ARTHUR H. FOORD, F.G.S.

THE genus *Actinoceras* was founded by Bronn in 1837,[1] upon Dr. Bigsby's figures in the Transactions of the Geological Society ;[2] the chief distinguishing character being the possession of a large, dilated, and segmented siphuncle, filled with radiating deposits. The presence of a smaller internal tube with tubuli radiating therefrom and communicating with the septal chambers through the wall of the siphuncle, had not then been observed.

FIG. 1.

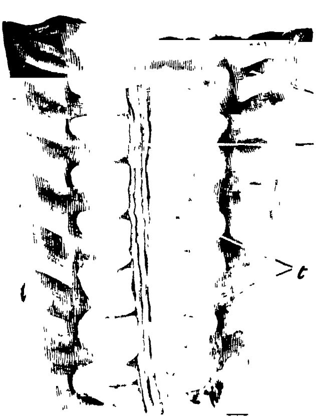


FIG. 2.

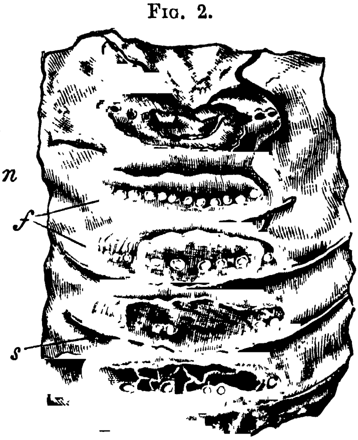


FIG. 1. Weathered fragment of *Actinoceras Bigsbyi*, showing the endosiphon, *en*, with some of its tubuli, *t* (thickened by incrustations of pearl-spar), *s*, septa. Nat. size. From the Black River Formation of Thessalon Island, Lake Huron.

FIG. 2. Fragment of the same species, showing the foramina, *f*, in the walls of the siphuncle, by which the tubuli thrown out by the endosiphon may have communicated with the septal chambers; *s*, septa. Natural size. From the Cincinnati Group, Versailles, Kentucky.

[1] Lethæa Geognostica, Zweite Aufl. Band i. p. 97.
[2] Ser. 2, vol. i. 1824, p. 198, pl. xxv. figs. 1, 2 (excl. fig. 3).

Actinoceras has been recognized, either in a generic, or in a sub-generic sense (under *Orthoceras*) by Stokes, Portlock, M'Coy, d'Orbigny (as equivalent to *Conotubularia*, Troost), S. P. Woodward, Hall (under the name of *Ormoceras*, Stokes), Saemann, Barrande, Ferd. Roemer, d'Eichwald, Owen, H. Woodward, Whitfield, Blake, and Hyatt.

The above figures have been drawn from specimens in the British Museum, and are designed chiefly to illustrate the structure of the siphuncle, in which the characters of the genus reside.

The shell in some species of *Actinoceras* (e.g. *A. giganteum*) is very large, in others it is of medium size; it is straight, or slightly bent in the young shell, and is circular or subcircular in cross-section. The sutures are usually more curved than they are in *Orthoceras*, the necks or recurved portions of the septa are very short, and are often incrusted with crystalline deposits ("anneaux obstructeurs" of Barrande), and these sometimes fill the spaces in the siphuncular cavity not occupied by the endosiphon and the tubuli proceeding from it. The siphuncle is sometimes very large in proportion to the shell, it may be equal to half the diameter of the latter; it is considerably dilated between the septa, forming thereby a series of segments of a compressed-globular shape. The first of these is broadly conical, and is perforated just above the apex with a large foramen, which served as a passage for the endosiphon from the initial chamber into the siphuncular cavity. The shelly wall of the segments is rarely preserved, but their calcified lining membrane beneath is very characteristic, presenting a series of longitudinal folds or wrinkles. The endosiphon (Fig. 1, *en*) is provided with a distinct wall, and gives off, at intervals between the septa, a number of radiating canals or tubuli (Fig. 1, *t*) which are seen to penetrate the wall of the siphuncle, and thus to communicate with the septal chambers, to which they may have conveyed blood-vessels, as suggested by Owen.[1]

The structure to which I desire now to direct particular attention is the perforation in the apex of the first segment of the siphuncle. There can be no doubt that this is strictly analogous to the perforation in the apex of the siphuncle in *Piloceras*,[2] and that through this opening the endosiphon passed from the initial chamber into the siphuncular cavity.

The rare preservation of the apical extremity of any of the straight shelled Cephalopods of the genera *Orthoceras*, *Endoceras*, *Actinoceras*, or *Piloceras*, imparts a peculiar interest and value to the specimens which are the subject of the latter part of this note.

It is to be hoped that by diligent search other specimens may yet be found which will throw more light upon these remarkable structures.

[1] Palæontology, 1860, p. 85.

[2] See paper on this genus by the present writer in the GEOLOGICAL MAGAZINE for December, 1887.

Fig. 3.

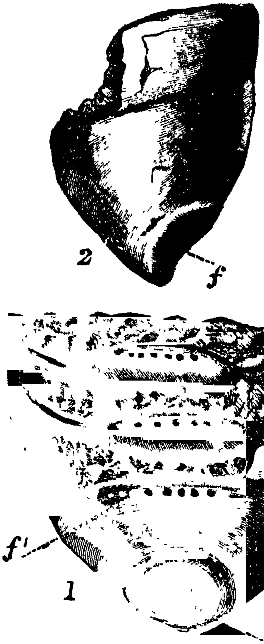


Fig. 4.

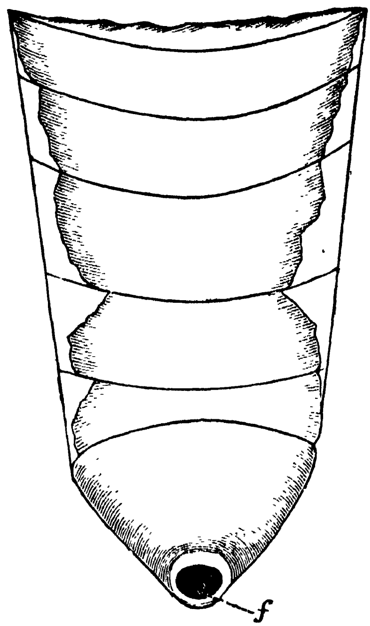


Fig. 3. 1, front view of a weathered fragment of the apical extremity of *Actinoceras Bigsbyi?*; showing (*f*) the large foramen and the row of minute foramina situated at *f′*, the most elevated part of the siphuncular segments. Natural size. From the Black River Formation (?), Igloolik Island, Arctic America.

Fig. 4. View of part of a much eroded fragment of an *Actinoceras*, consisting of the internal cast of some of the septal chambers, and the siphuncular segment with its foramen (*f*). Three-quarters natural size. Fig. 3.—2, side view of part of the same specimen, showing the lateral position of the large foramen (*f*) in relation to the apex. Natural size. From the Great Slave Lake, British North America.

IV.—Some Definitions in Dynamical Geology.

By W. J. McGee;

Of the United States Geological Survey, Potomac Division, Washington, D.C.

In view of the active discussion of the problems of earth-movement and mountain-growth now current, certain fundamental definitions, growing out of the discrimination of processes commonly confounded but really distinct, seem to be timely.

The various processes with which the geologist has to deal fall naturally into two principal and antagonistic categories and five subordinate and supplemental categories; and each category, great and small, comprises two antagonistic classes of movements or agencies.

The initial geologic movements (so far as can be inferred from the present condition of the rocks of the earth) were distortion or

displacement of the solid or solidifying terrestrial crust in such manner as to produce irregularities in the surface of the globe. These are the movements involved in mountain-growth and in the elevation of continents; they have been in operation from the earliest eons recognized by the geologist to the present time; and their tendency is ever to deform the geoid and produce irregularity of the terrestrial surface. Such movements have been designated "displacement," "diastrophism," etc.; but for the present purpose they may be called simply *deformation*, and the quality of the movement may be characterized as *diastatic*. They are partly vertical (though there is perhaps always a horizontal element) and are most easily measured from a fixed datum-plane—such as sea-level—and are therefore commonly separated into *elevation* and *depression*.

The second great category of movements comprises the various processes of aqueous erosion and deposition initiated by the primary deformation of the terrestrial surface. By these processes mountains and continents are degraded, and seas and lakes are filled with their debris; they, too, have been in active operation from the dawn of geologic history to the present; and they ever tend to restore the geoid by obliterating the irregularities of the terrestrial surface produced by diastatic movement. Collectively the processes may be called *gradation*; and the antagonistic operations comprehended under the term are respectively *degradation* and *deposition*.

A subordinate class of processes by which the rocks of the earth are formed or affected is the extravasation of lavas and other volcanic matter from beneath the surface, the outflow of subterranean waters containing solid matter in solution, and the escape of mineral-charged gases, together with the consequent collapse of cavities and other crust-movements. These processes have been in operation throughout geologic time, though perhaps with diminishing activity; they have added materially to the superficial strata of the earth; and they have modified the geoid not only by addition without, but by the commensurate loss within and consequent deformation and structural alteration. The various operations are commonly comprehended under the term *vulcanism*; and the two subordinate classes or processes of antagonistic tendency which it comprises are *extravasation* and its converse. The vibratory movements usually called seismic probably accompany both diastatic and volcanic movements under certain conditions.

The second subordinate category of processes by which the rocks themselves and the operations of the second great category of geologic processes are modified, comprises the chemic and chemico-mechanical alterations in structure of the earth's strata brought about by the action of percolating water, air, and other gases, the effects of frost and other variations in temperature of the exterior of the earth, the rise of the isogeotherms beneath the areas of degradation, the heat resulting from deformation, etc. These processes have affected the rocks ever since the solidification of the planet, but probably with progressively diminishing intensity; by them the rocks exposed to degradation are disintegrated, decomposed,

and softened, and degradation is thereby accelerated; by them the soft sediments are first lithified and then (sometimes) subsequently metamorphosed; and by them the chemic complexity and structural heterogeneity of the terrestrial crust have been largely produced. The various processes are processes of *alteration;* and they comprise *lithifaction* and its converse (*decomposition* and *disintegration* combined) in their various phases, or rock-formation and rock-destruction.

There is another subordinate category of processes which are intimately allied to those of the second great category, viz. *glaciation.* Only two clearly defined periods of extensive glaciation—both late Tertiary or Quaternary—are generally accepted, though others are recognized by different geologists; in general the tendency of glaciation is to obliterate surface-irregularity, both by grinding down elevations and filling up depressions, and thus to perfect the geoid; but glaciation may also accentuate pre-existing irregularities of the surface, certainly by moraine-building and probably by basin-cutting, and must therefore be set apart as a unique agency in the modification of the external configuration of the globe. The general process comprises *glacial construction* and *glacial destruction.*

The fourth subordinate category includes the effects of aerial circulation, directly upon land surfaces, and indirectly through wave and current-action under and about water surfaces. These processes have been in operation throughout geologic time, but so indolently that little trace of their products is found save among recent phenomena; in general the tendency is to reduce elevations and fill depressions, and thus to merge into gradation; but there is also a tendency to build dunes, beaches, and banks, and to excavate both subaerial and subaqueous basins, and thus to produce certain minor irregularities of the earth's surface as well as to perpetuate others. The general process is *wind action* or *eolation*; and its subordinate processes are, like those of other categories, antagonistic.

There is a final category which is in part allied to alteration, but which is in part unique, viz. the chemic, chemico-mechanical, and dynamic action of organic life. Ever since the terrestrial crust became so stable as to retain a definite record of the successive stages of world-growth, life has existed, and by its traces has furnished the accepted geologic chronology; at first the organisms were simple and lowly and affected the rocks chemically through the processes of growth and decay, as do the lower plants and animals of the present; later, certain organisms came to contribute largely of their own bodily substance to the growing strata; and still later the highest organisms, with man at their head, have come to interfere with gradation, alteration, and eolation dynamically, and thus to directly or indirectly modify the various interrelated geologic processes—indeed it is probable that in populous plains at least the several natural processes combined are less potent factors in geologic development than human action alone. The vital forces are too varied in action to be conveniently grouped and comprehensively named.

This simple classification of elementary processes, which appears

to practically traverse the domain of geologic science, is summarized in the accompanying table :—

Classification of Geologic Processes.

Principal Categories.	1. Deformation	Elevation Depression
	2. Gradation	Degradation Deposition
Subordinate Categories.	1. Vulcanism	Extravasation Converse of do.
	2. Alteration	Lithifaction Converse of do.
	3. Glaciation	Glacial construction Glacial destruction
	4. Eolation	Eolic construction Eolic destruction
	5. Vital action	Various constructive and destructive processes.

The first principal category of processes is supplemented by the first subordinate category, and both tend to produce departures from the simple geoidal form or *heteromorphism.* Play is thus given to the operations of the second principal and the last four subordinate categories, which are also intimately related, and, combined, tend to produce *heterogeneity* in the external shell of the earth. The joint result is *differentiation* of the earth's exterior—the converse of those processes of concentration and segregation by which the planet was originally formed ; and the passage from the stage of segregation to that of differentiation represents at the same time the senescence of the planet and its entrance into the state recognized by the geologist *per se.*

Now the processes involved in heteromorphism are generally obscure, and many of them are beyond the reach of observation. Here, moreover, the domain of the physicist and astronomer on the one hand and that of the geologist on the other overlap ; here the physicist contributes principles and makes deductions of great suggestiveness and often of high value to the geologist, and here the geologist is an agnostic and assails the deductions of the physicist, and, too often for the good repute of physical science as applied to geologic research, breaks them down ; here, too, the geologist is equally an agnostic with respect to his own conclusions of higher rank than mere generalizations, and assails every inference of his fellows and, unless he be rash indeed, guards his own course at every step and feels his way cautiously through the tangled maze of ambiguous testimony recorded in the crumpled strata of the mountains ; here the dearth of clear definitions of the various processes of deformation is doubtless due to the hesitation of physicist and geologist alike to confidently enter the purview of the adjacent domain ; but here tentative definitions (at least) are especially needed, and indeed essential to the progress of research.

Within about a decade an inference of moment concerning diastatic movement has been made (largely by American geologists), viz. that certain orogenic and even volcanic movements are consequent

upon gradational transfer of matter—that the earth is in a condition of isostacy, and that as the rains bear detritus from the mountains into the seas, the unloaded mountains rise and the loaded sea-bottoms sink, and thus that a part of the deformation of the outer shell of the earth and certain volcanic movements are consequent upon the processes of gradation. Although at first blush it might appear that the great problem of earth-movements is solved by this discovery, consideration shows that these consequent diastatic and volcanic movements are but the indirect result of antecedent movements for which no adequate cause has been assigned (unless the "contraction theory" be accepted); for it is evident that if deformation were dependent solely upon transfer of sediments, it would diminish with the lapse of time, that the mechanism of mountain elevation would soon become clogged by increasing friction, and that the terrestrial surface would quickly be graded so completely that further movement would cease; yet the rocks record diastatic activity throughout geologic time, now increasing, now diminishing, but on the average probably increasing rather than diminishing, and perhaps as potent to-day as during any past time. So the processes by which heteromorphism are produced are separable into two classes—that depending upon transfer of sediments, which may be designated *consequent*, and that for which adequate cause has not yet been assigned, which may be called *antecedent*. Discriminated upon a different basis they fall into classes approximately but not exactly coinciding with these, viz. *orogenic*, or mountain-making movements, and *epeirogenic*,[1] or continent-making movements.

Now it is only within a decade that diastatic and volcanic movements of the consequent class have been separated from the primary class; even yet there are geologists who do not recognize the distinction; and so most of the hypotheses thus far framed to explain the deformation of the terrestrial shell rest upon the explicit or implicit assumption that all the movements involved belong to the class here called antecedent. The appositeness of the definitions therefore needs illustration.

A primary hypothesis ascribed the corrugation of the terrestrial crust to contraction of the interior of the earth accompanying secular cooling more rapid than that of the exterior shell. The common conception of the mechanism of this process was familiarly illustrated by likening the corrugated globe to a withered apple, and the inequalities of the terrestrial surface to the wrinkles on the apple's skin; and to the surprise of most American geologists, at least, this hypothesis has been prominently advocated within a year or two. Fisher and others have shown, however, that the postulated cause is far from commensurate with the observed effect—that even upon the most liberal estimates of radial contraction due to secular cooling, the concomitant tangential contraction would scarcely produce a tithe of the observed corrugation of the terrestrial crust. Dutton maintains that equitable contraction of a spheroid would not tend to produce corrugations such as those characterizing the earth's

[1] A term proposed by Gilbert.

crust. Taylor and others have pointed out that any corrugations resulting from secular cooling of the terrestrial shell in combination with the stresses resulting from precession, nutation, retardation of axial rotation, etc., would tend to assume certain definite directions, and that these directions do not coincide with those of the mountain ranges actually existing nearly enough to give countenance to the hypothesis. Reade and others have recently found that tangential contraction due to secular cooling must have been confined to a limited shell, even thinner than the strata known to be corrugated; and it might be demonstrated that the concentration of montanic corrugation along certain lines, leaving vast intervening areas quite undisturbed, does not agree with the hypothesis, and could not occur in accordance with it under any conditions of rigidity and internal friction of the rocks which it is reasonable to assume—the arches are too long and rest too heavily upon the terrestrial nucleus to convey crushing strains to their extremities without greater compression about their keystones. While therefore the "contraction theory" is so conditioned as to explain antecedent deformation, it cannot be accepted as a quantitatively adequate cause of such movement.

There is another hypothesis of earth-movement frequently regarded as alternative with the last. Geologists and physicists have long ageed that lines of mountain growth usually coincide with zones of rapid deposition during former times, and that in these zones the deposition was accompanied by depression (thus foreshadowing the later conception of consequent diastatic movement); they have agreed further that in consequence of the combined sinking and thickening of the crust, the couches of equal temperature within the earth—the isogeotherms—must rise in the sediments until strata formed at the temperature of the sea-bottom are heated to hypogeal temperatures; and they have inferred that the consequent expansion of sediments developed stresses whereby further heat was generated, and that the rocks were thus flexed, corrugated, and sometimes metamorphosed. This hypothesis, in one form or another, has had currency for a generation. It has indeed been questioned whether the assumed cause is commensurate with the effect—whether the expansion of sedimentary beds by local rise of isogeotherms from time to time and from place to place is sufficient to explain the extensive and profound corrugation observed in the mountains of the earth, the enormous shortening of the Alpine arc as observed by Heim and others, and the shortening of the Appalachian arc by 60 miles as computed by Claypole; but Reade has quite recently pointed out what the early advocates of the hypothesis had overlooked, viz. that since the strata are confined laterally, any expansion due to rise of temperature must take place vertically, so that a given rise of temperature would produce thrice the elevation and perhaps thrice the corrugation inferred by the older geologists; and the hypothesis has thus been rendered more acceptable.[1] But

[1] Singularly, Reade and all his predecessors neglected an important (in the judgment of the writer the most important) factor in the movements contemplated

it is evident that all such movements belong to the consequent class as above defined, and hence that the hypothesis utterly fails as an explanation of the antecedent deformation by which active geologic processes were initiated early in the history of the earth, and by which these processes have ever since been maintained. It cannot be too strongly emphasized that without continents zones of deposition could not be formed, and that continents could not come into being without antecedent deformation. The case is simple. Either (1) the primaval earth was highly rugose, and gradation and consequent deformation have always been employed in reducing the rugosity, or else (2) a general deforming force of unknown cause and value has always been in operation—either the earth is a clock once wound up and ever since running down, or it is a prime motor whose mechanism may be obscure, but whose energy is ever renewed within itself. To the working geologist, constrained by the inexorable logic of facts, there is but one choice between these alternatives; the Palæozoic earth, at least, was less rugose than the present, and although diastatic activity has varied, it has not declined with the ages; and the grander earth-movements are in progress to-day as proved by a score of examples of continental oscillation, and is perhaps as active now as at any time in the past.

So the processes by which heteromorphism of the globe are produced (deformation and vulcanism combined) comprise (1) movements antecedent to gradational transfer of matter, predominantly epeirogenic, or continent-making, and predominantly diastatic, for which adequate cause is not yet assigned; and (2) movements consequent upon gradational transfer of matter, predominantly orogenic, or mountain-making, and both diastatic and volcanic. It is important to discriminate these classes of movements.

in the hypothesis. Lines of sedimentation are the margins of continents, and the sediments are laid down not upon horizontal surfaces, but upon seawardly sloping bottoms; so the sediments do not form horizontal beds, but take a variable seaward slope determined by marine currents, wave action, etc. Thus the mass of sediments is collectively in the condition of a mass of snow upon a roof or upon a mountain side, *i.e.* in a condition of potential instability or *inequipotentiality*. If the mass is stable in either case, it is because the friction among the particles exceeds the attraction of gravitation upon the particles; it is obvious that if particle friction were reduced by augmentation of temperature or by alteration of constitution, or if the efficiency of gravitation were increased by addition to the mass, the point of stability might be passed, when the mass would move in the direction of the slope; and it is equally obvious that if an inequipotential mass expand, the resulting movement will not take place equally in all directions, but mainly or wholly in the direction of least resistance, which is that of the slope. Since the sediments fringing continents are in a condition of inequipotentiality, any movement due to the rise of isogeotherms or other cause must take place in a single direction; and it might not be limited to that due to expansion, for other factors co-operate. Supplemented by this additional conception, the hypothesis of mountain growth so ably advocated by Herschel, Babbage, Hall, Dana, Le Conte, Reade, and a score of others, appears to gain much in acceptability.

V.—On the Cretaceous Selachian Genus *Synechodus*.

By A. Smith Woodward, F.G.S., F.Z.S.,
of the British Museum (Natural History).

MORE than forty years ago the detached teeth of Hybodont Sharks were recognized by Reuss[1] in the Cretaceous rocks of Bohemia, and these were referred to the genus *Hybodus* under no less than eight specific names. About twenty years later, evidence of a somewhat similar Selachian was discovered by Mr. William Davies and Mr. S. J. Mackie, in the Lower Chalk of Kent; and the cartilages of the jaw, with a few teeth, were briefly described by the last-named geologist[2] under the name of *Hybodus dubrisiensis*. In 1886, the present writer pointed out,[3] from more recently discovered specimens, that the English Cretaceous species was more specialized in every respect than any of the typical forms of *Hybodus*; and quite lately it has been proposed[4] to regard this fossil as generically distinct, with the new name of *Synechodus*.

It now appears, indeed, that "*Hybodus*" *dubrisiensis* is much more nearly related to *Palæospinax* than to the typical *Hybodus*. This is well shown by the almost complete dentition of one jaw, exhibited in a fine specimen from the Chalk of Sussex, preserved in the Willett Collection in the Brighton Museum; and the opportunity of making known this important new fossil—kindly afforded by Henry Willett, Esq., and the Chairman of the Museum Committee (Edward Crane, Esq.)—seems a fitting occasion for briefly summarizing our present knowledge of the skeletal and dental characters of the fish. All the cartilages are only superficially calcified, but the thin hardened layer is comparatively resisting, and it has thus been sufficiently preserved in some cases to indicate the precise contour of several parts of the skeleton.

Head.—Nothing worthy of note has been observed in connection with the cranium; but the mandibular and hyoid arches are well known and of great interest.[5] A facette upon the superior border of the pterygo-quadrate cartilage may almost certainly be regarded as indicating a post-orbital articulation with the cranium; and in correspondence with this arrangement the hyomandibular element is remarkably slender. There is thus considerable resemblance between the skull of *Synechodus* and that of the existing *Notidanus*; both exhibiting a very primitive condition of the mandibular and hyoid arches, and showing a tendency to specialization in one and the same direction.

1 A. E. Reuss, "Verstein. böhm. Kreideform.," 1845-6, pt. i. p. 2; pt. ii. pp. 97, 98, with figs.

2 S. J. Mackie, "On a new species of *Hybodus* from the Lower Chalk," The Geologist, vol. vi. (1863), pp. 241-246, pl. xiii.

3 Smith Woodward, "On the Relations of the Mandibular and Hyoid Arches in a Cretaceous Shark (*Hybodus dubrisiensis*, Mackie)," Proc. Zool. Soc., 1886, pp. 218 224, pl. xx.

4 Smith Woodward, "A Synopsis of the Vertebrate Fossils of the English Chalk," Proc. Geol. Assoc. vol. x. (1888), p. 288.

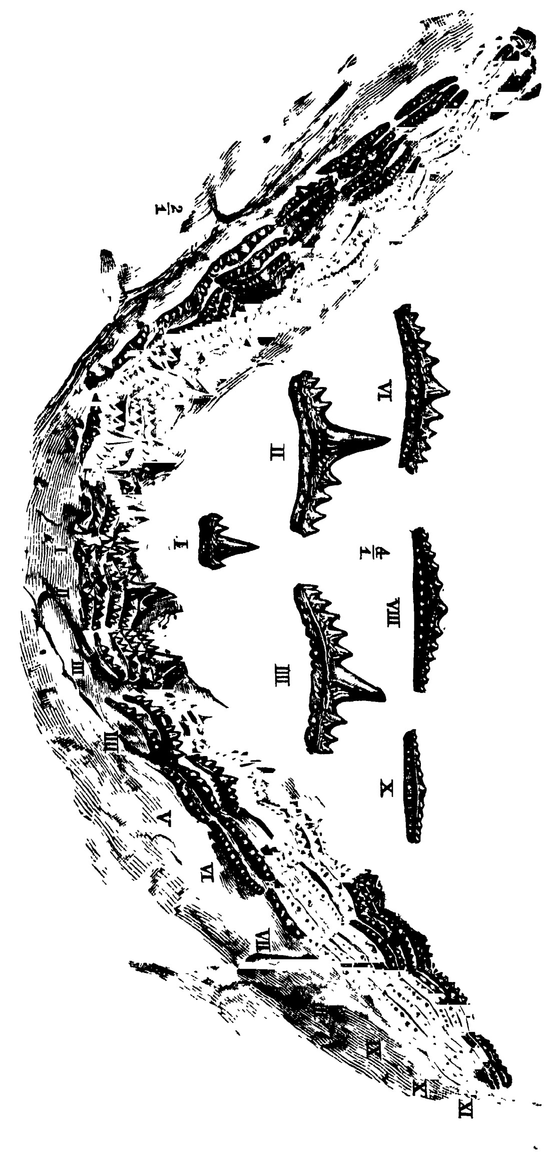
5 See figures in Proc. Zool. Soc. 1886, pl. xx.

Dentition.—In Mr. Willett's example of the dentition of *Synechodus dubrisiensis*, already referred to, about 140 teeth are displayed in their natural relative positions; and the fossil is shown, of twice the natural size, in the accompanying Woodcut, with the first and second teeth and one of each of the alternate succeeding series, still further enlarged separately. There are eleven dental series upon either ramus of the jaw, each of those posteriorly placed comprising as many as eight or nine teeth, while those near the symphysis have not more than six. There is no median symphysial row of teeth, and the first pair (I.) is extremely small. In the latter the principal coronal cusp is long and slender, its height being equal to the entire width of the tooth; and there are two small denticles in front and one behind. The teeth of series II. are nearly four times as wide as those of no. I., with the principal coronal cusp still very prominent and flanked in front and behind by three large denticles and one smaller point, of which those behind are the more widely spaced. The teeth of series III. are very similar to those of no. II.; but in the teeth of series IIII. and V. the principal cusp rapidly becomes stouter and less elevated, and there are five denticles in front, while only three or four can be distinguished behind. In series VI. to IX. the size of the teeth only gradually decreases backwards, but the principal cusp becomes very short and stout, thus more resembling the lateral denticles, which are still very numerous and placed well apart. In these teeth, the denticles are five or six in number, both in front and behind. In series X. the teeth are only about two-thirds as wide as those of no. IX., while those of series XI. are still smaller by one-half; and in both of these all the coronal prominences have become insignificant, though yet faintly indicated by a beaded contour. The base of the crown in all the teeth is marked by fine reticulating wrinkles, and the lower portion of the coronal cusps is often vertically striated.

On comparing the teeth of this fossil with the few examples of *S. dubrisiensis* already described, one important difference will at once be noted. Whereas in Mr. Willett's specimen, the most anterior teeth are very small and delicate, some other fossils exhibit teeth in a corresponding position of a very large and robust character, with several feebly marked denticles on each side.[1] One specimen in the British Museum (No. 41675) suggests that the latter pertain to the upper jaw; and, in that case, the Brighton fossil may represent the lower dentition. There can be no doubt, indeed, that the two types belong to one and the same species; but whether the differences in the anterior teeth depend merely upon their pertaining to one or the other jaw, or whether one type is referable to the male and the other to the female, remains yet to be determined. The present writer has examined no specimen in which the small teeth and the robust teeth occur together.

Axial Skeleton of Trunk.—The vertebral centra are well calcified; but only the anterior portion of the body is yet known (Brit. Mus.

[1] Proc. Zool. Soc. 1886, pl. xx. fig. 3*a*.



Dentition of *Synechodus dubrisiensis*, Mackie sp.; Chalk, Sussex.

[Collection of Henry Willett, Esq., F.G.S., Brighton Museum.]

No. 49032). All the vertebræ are distinctly "asterospondylic" in structure, and the centra are mostly deeper than long.

Appendicular Skeleton.—Each half of the pectoral arch consists of a single slender cartilage, produced upwards into an attenuated extremity, and very similar in form to the corresponding element both of *Palæospinax* and of *Hybodus*.

External Dermal Structures.—A fine, apparently sparse shagreen covered at least certain portions of the body; and a few of the granules are well preserved upon one small fragmentary head in the British Museum. Some granules are smooth and quadrate in form, but many are more or less oval, ridged and grooved in the direction of their long axis.

Affinities.—The dentition of *Synechodus*, as long ago recognized, indicates the systematic position of the fish to be in the Hybodont section of the great family of Cestraciontidæ. Many of the detached teeth cannot be distinguished from those of *Hybodus*; but, as already remarked, a comparison of the complete dentition described above with the dentition of *Palæospinax priscus* from the Lower Lias of Lyme Regis,[1] shows a still more exact correspondence in almost every feature. With *Palæospinax*, also, *Synechodus* agrees in the character of its shagreen; and the vertebræ in the Cretaceous genus only differ from those of the Liassic fish in their slightly higher stage of development. The fact that no Selachian dorsal fin-spines have hitherto been found in the Chalk, except small smooth spines indistinguishable from those of *Cestracion* and *Palæospinax*, is also suggestive of the correspondence of the two genera under comparison in the nature of these dermal defences. The more specialized character of *Synechodus*, indeed, is the only justification at present for its generic separation; and it may be added that *Palæospinax* is certainly one of the Cestraciontidæ (Hybodontidæ), being definitely separated from the Spinacidæ, with which it has hitherto been associated, by the possession of a distinct anal fin (Brit. Mus. no. P. 1296).

Distribution.—The earliest evidence of *Synechodus* with which the writer is acquainted occurs in the Neocomian of Kent, whence have been obtained some anterior teeth with an attenuated principal coronal cusp. Other teeth have been described from the Lower Cretaceous of Amuri Bluff, New Zealand, under the name of *Odontaspis sulcata*.[2] A few teeth, of still another specific type, are met with in the English Gault. A single example from the Cambridge Greensand is preserved in the collection of Thomas Jesson, Esq., of Northampton. *S. dubrisiensis* occurs in the Lower, and probably also in the Upper Chalk; there is evidence of other forms in the uppermost Chalk of Norfolk; and one or more species are represented in the Lower Chalk of Saxony, Bohemia, and Russia.

[1] Sir Philip Egerton, "Figs. and Descrips. Brit. Organic Remains" (Mem. Geol. Surv.), dec. xiii. (1872), pl. vii.

[2] J. W. Davis, "On the Fossil Fish Remains of the Tertiary and Cretaceo-Tertiary Formations of New Zealand," Trans. Roy. Dublin Soc. [2] vol. iv. (1888), p. 25, pl. v. figs. 11—13.

VI.—Note on the Occurrence of a Species of *Onychodus* in the Lower Old Red Sandstone Passage Beds of Ledbury, Herefordshire.

By A. Smith Woodward, F.G S., F.Z.S.;
of the British Museum (Natural History).

During a recent visit to the University Museum at Oxford, I observed in the Grindrod Collection an interesting small fossil apparently adding to the known fauna of the Ledbury Passage Beds a remarkable type of fish, hitherto only met with in the Middle and Upper Devonian of the United States. Through the kindness of Professor Green, I have since had the opportunity of studying this specimen in London; and it is shown, of twice the natural size, in the accompanying Woodcut. It may be regarded as an imperfect example of the so-called "intermandibular arch" of the extinct ganoid, *Onychodus*, described by Prof. Newberry[1] from the Corniferous Limestone of Ohio, and the Chemung Group of Delaware County, New York.

The fossil is, for the most part, only displayed in section, owing to the unfortunate plane of fracture of the matrix; but the uppermost of the vertical series of teeth, as preserved, exhibits the unbroken outer surface for about half of its length, and this enables

Intermandibular Arch, or Presymphysial Bone, of *Onychodus anglicus*, A. S. Woodw., Lower Old Red Sandstone Passage Beds, Ledbury, Herefordshire. Twice nat. size. [Grindrod Collection, University of Oxford.]

the cylindrical form and unornamented character of the dental crown to be determined. There is a curved plate for the attachment of the teeth, scroll-shaped in section, the attenuated lower extremity being considerably in-rolled. The teeth have the *appearance* of being directly fused to the base, arranged along its convex side; and they obviously decrease in size from above downwards, though the distal portions of all but the uppermost are considerably destroyed. The upper tooth, as already remarked, is slender and cylindrical in section, with a smooth surface, perhaps only marked with one faint longitudinal groove on each side; and the distal half of the crown is sharply directed upwards. Beneath this tooth are prominent remains of three others, similarly shaped, and closely placed together at their bases; and evidence of either one or two still smaller teeth is distinguishable yet more inferiorly.

Ferruginous matter has penetrated the interstices of the fossil,

[1] J. S. Newberry, Geol. Survey of Ohio, vol. i. pt. ii. (Palæontology), pp. 296—302, plates xxvi., xxvii.

and so rendered its minute structure to a certain extent recognizable. The base is conspicuously vascular, except in a thin, sharply-defined layer forming the concave margin; and each tooth is likewise constituted mostly of vascular tissue, with a thin, dense outer layer. A very small cavity also appears to occupy the centre of each dental cone.

The genus *Onychodus* was originally founded by Prof. Newberry upon detached teeth similar to those of the Ledbury fossil, discovered in the Corniferous Limestone of Ohio. These teeth were at first supposed to be referable to the great Placoderm, *Macropetalichthys*, occurring in the same beds; but their discovery soon afterwards in connected series naturally led to the suspicion that they might rather pertain to a Selachian. Still later, the problematical dentition was found associated with cranial plates, tooth-bearing maxillæ and dentary bones, and numerous round scales; and in 1873, complete proof of its exact position in the jaws of the original fish had at last been obtained. It appears that the slender bony arch is a mesial element fitting in a well-marked groove at the symphysis of the dentary bones; while the long, sigmoidally-curved teeth project directly forwards in front. The head-bones are numerous, and the large round scales are deeply overlapping, being ornamented much like those of *Glyptolepis*; whence Prof. Newberry concludes that *Onychodus* was most probably one of the great group of Crossopterygidæ.

The fossil now under discussion is thus referable to a "Ganoid," and it evidently represents the presymphysial bone of some later genera (e.g. *Aspidorhynchus* and *Belonostomus*), even if it be not altogether homologous with that element. The appearance of the series of teeth is at first suggestive of a dental succession like that of Selachians; and in this connection it would be interesting to know precisely the histological characters of the fossil. Though comparatively abundant, none of the American examples seem to have been yet examined microscopically; but it is to be hoped that some such investigation may soon be made—more especially as comparisons have already been suggested with the problematical Carboniferous *Edestus*.[1]

The coiling of the inferior extremity of the base in the Ledbury fossil has not hitherto been noted in the American specimens; and this may be either a normal feature, or merely a post-mortem accident to a possibly pliable tissue. Other differences, however, of at least specific value, are also observable between this and the described American types of "intermandibular arch": the new fossil is much smaller than those already known, and the size of the teeth is apparently less uniform. Awaiting further evidence, therefore, for more precise definition, the species of the Ledbury Passage Beds may receive the name of *Onychodus anglicus*.

[1] Fanny R. M. Hitchcock, "On the Homologies of the so-called Spines of *Edestus*," Proc. Amer. Assoc. Adv. Sci. 1887. See also J. S. Newberry, "On the Structure and Relations of *Edestus*," Ann. New York Acad. Sci. vol. iv. (1888), p. 116.

VII.—Note on Mr. I. C. Russell's Paper on the Jordan-Arabah and the Dead Sea.

By Professor Edward Hull, LL.D., F.R.S.

I HAVE been very much interested in reading Mr. Russell's two communications published in the Geological Magazine for August and September last.[1] The analogy which he draws between the history of the Dead Sea valley and that of some of the lake valleys in the western part of North America is instructive as showing how similar physical features can be accounted for on similar principles of interpretation over all parts of the world. Mr. Russell very properly draws attention to the paper by his colleague Mr. G. K. Gilbert on "The Topographical Features of Lake Shores," in which principles of interpretation of physical phenomena are laid down applicable to lakes both of America and the Jordan-Arabah valley.[2] With some of Mr. Russell's inferences regarding special epochs in the history of this valley I am very much disposed to agree; more particularly in reference to the mode of formation of the Salt Mountain, Jebel Usdum; or rather, of the salt-rock which forms the lower part of its mass. If this interpretation be correct, it removes the difficulty of understanding why the rock-salt is confined to one small corner of the lake, which, at the time the salt was in course of formation, was vastly more extensive than at present.

The case of the arm of the Caspian known as Kara Bughaz, which Mr. Russell cites, seems remarkably apposite to that of the Southern bay of the Dead Sea; and I feel obliged to the author for his suggestion. In reference to Mr. Russell's statement that "we ought to look for an unconformity between the upper and lower lake beds due to the erosion of the lower member," I wish to take this opportunity of referring again to the peculiar structure in the rock-salt near the northern end of Jebel Usdum, where the white laminated marls, forming the upper part of this plateau, are seen resting horizontally on a mass of rock-salt, having an oblique structure; that is, traversed by planes sloping southwards at an angle of about 20°–25°. I made a sketch of this part of the cliff in my note-book, but from inability, through lack of time, to examine into the phenomena with more care than can be done from horse-back, I thought it prudent not to refer to the matter in the Geological Memoir,[3] further than to notice it.

My special purpose in this communication is to offer some additional information to that already given on the question whether or not the Jordan-Arabah valley originally communicated with the ocean through the Gulf of Akabah. Mr. Russell is not satisfied with the information already before him regarding the nature of the watershed of the Arabah. I have, therefore, referred back to my

[1] "The Jordan-Arahab Depression and the Dead Sea," Geol. Mag. Aug. and Sept. 1888, pp. 337–344 and 387–395.
[2] Gilbert, Fifth Annual Report U.S. Geological Survey (1883–84).
[3] Memoir on the Physical Geology of Arabia-Petræa and Palestine, p. 84 (1886).

notes, which are rather full on this very subject, though I did not consider it necessary to give them *in extenso* in the Geological Memoir, or in Mount Seir. On referring to the large Map of the Arabah Valley in the Memoir (facing p. 137), it will be seen that the watershed (Lat. 30° 10′ N.) is formed partly of a limestone ridge, called Er Rishy, and partly of "gravel of the Arabah." This gravel extends for several miles down both slopes of the watershed, and is sometimes overspread by blown sand, or else by alluvium. On the west side it is bounded by the steep, often precipitous, cliff of the rocks forming the eastern border of the Desert of the Tîh (Badiet et Tîh), and on the east by those of the Edomite hills and escarpments; and at its lowest part rises about 700 feet above the level of the Mediterranean and Red Seas,[1] and therefore nearly 2,000 feet above the present surface of the Dead Sea. On approaching the watershed, or saddle, from the south, it appears as a level line stretching from the northern end of Er Rishy to the foot of the rugged hills of Edom, and about half a mile in length. It is formed of sand and gravel of considerable thickness overlying the limestone which rises from beneath on the eastern side, and which is broken off by the great Jordan-Arabah fault against the granitoid and other crystalline rocks, which here form the base of the Edomite range. This gravel has all the appearance of a fluviatile, or alluvial, deposit, formed by the streams which in flood time descend from the hills to the east; and it is well laid open to view in one of these streams, which ultimately joins the River Jeib. Between this watershed and the first of the terraces which can, with any degree of certainty, be referred to a lacustrine origin, there is a distance of over twenty miles, and a vertical fall of about 700 or 650 feet; and as our party was scattered over the valley, we could not have failed to detect remains of such lacustrine deposits, if any such existed, above the level of those we encountered at our camp of the 12th December, 1883, at Ain Abu Werideh: at a level approximately that of the Mediterranean, and 1292 feet above that of the Dead Sea.[2] These horizontal beds of white marl with shells, sand, and shingle, was an entirely new feature to us all; and no doubt remains on my mind that they indicate the highest level to which the waters of the ancient Jordan-valley Lake formerly rose.

An admission on my part that the waters of the Jordan valley ever were in connection with those of the outer ocean through the Gulf of Akabah can only be made from the point of view that, during the formation of the Jordan-Arabah line of depression by the displacement of the strata along the great fault, and when the whole region was rising from beneath the waters of the ocean in Miocene times, some such connection existed for a limited period of time; but this epoch in the history of the valley was separated by a long interval from that of the present Dead Sea, even when standing at a level of 1300 feet above its present surface. From the time that

[1] M. Vignes' determination is 787 feet (240 mètres); that of Major, now Colonel Kitchener, is 660 feet; and that of Mr. Reginald Laurence by aneroid 650 feet.

[2] Mount Seir, p. 99; Geological Memoir, p. 80.

the outer waters of the ocean were dissevered from those of the Jordan-Arabah lake by the up-rise of the land, there is no evidence that there was ever any subsequent connection by means of a stream flowing down from the North into the Gulf of Akabah. The closest approximation which, according to my view, these inner and outer waters ever made towards each other is represented in the sketch-map of that whole region in page 72 of the Geological Memoir, where a tract of ground of about 40 miles in length and rising to 700 feet in height is represented as intervening between their respective borders.

VIII.—On Some Rock-Specimens from Socotra.

By Miss C. A. Raisin, B.Sc.

These specimens were collected in Socotra, near the coast, by Colonel M. Gosset, and were sent to Prof. Rupert Jones. By the kindness of Prof. Bonney I have been allowed to carry on the examination of the rocks, at University College, in connection with the Somali specimens already described.

Granites.—The granites need little description, as they are clearly of types already obtained from Socotra;[1] they consist chiefly of felspar, often microcline, and of quartz. Hornblende crystals, evidently of early consolidation, are imbedded in the felspar. Some of the hornblende is very strongly dichroic, and changes from a faint green to a deep peacock-blue, tints which approach somewhat near those shown by glaucophane. Octahedra of magnetite occur in one fragment, and in others characteristic crystals of zircon are fairly abundant.

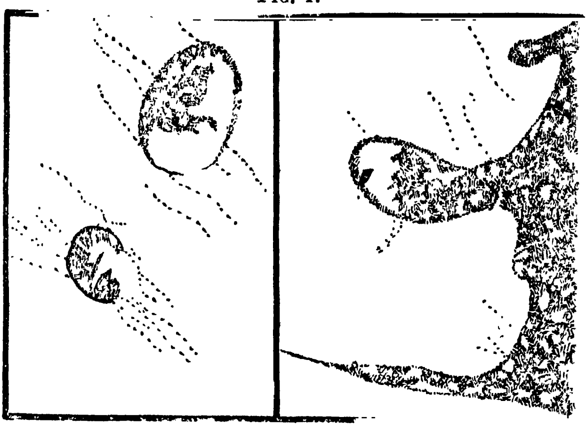
Felstones.—Many of these seem to be quartz-felsites of the red and purple tints, mentioned by Prof. Bonney as so characteristic of Socotra. Two specimens, however, need somewhat fuller description.

(1). Quartz-felsite. This is a very compact, flinty rock, dull-green in colour, blotched with white. The ground-mass is completely devitrified, with small brightly-polarizing microliths scattered through it. The porphyritic hornblende is in partial preservation, but frequently epidote appears to have formed along its cleavage-planes, and spread over the interior of the crystal. Many of the felspars are plagioclase; some have passed to an aggregate of crystalline films, but others appear clarified, with kyanite-like cleavages. The porphyritic quartz is much corroded. Some of the embayments formed of the ground-mass inclose clear, unaltered quartz, generally with a shadowy outer border, as if it had been partially melted down by the surrounding matrix (Fig. 1). In other examples, the invading ground-mass, which has an angular outline, stops short of a curved boundary, marked out by minute cavities often with moving bubbles. Corrosion of crystals has been attributed to the influence of a direct rise of temperature, or indirectly to some cause which increases the fusibility of the matrix and solubility of the crystal, such as an alteration in the amount of

[1] Phil. Trans. 1883, p. 282, On a Collection of Rock Specimens from the Island of Socotra, Prof. Bonney.

pressure,[1] or the introduction of water.[2] If the change in the condition of the rock were rapid, a contraction might result, and might perhaps develope along a curve, a layer of inclosures, as in the effects from pressure demonstrated by Prof. Judd.[3] The strain increased, the curve might become a crack, so that the corroding magma could make its way along the weakened surface, and cause the

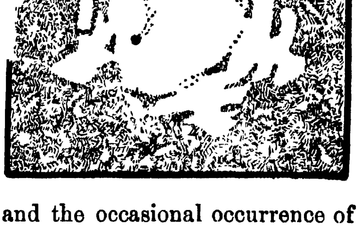
Fig. 1.



Figs. 1 & 2.—Porphyritic Quartz, which has undergone corrosion. The darkened part represents devitrified ground-mass including hornblende flakes. The dots are minute enclosures. The porphyritic quartz is left clear.

interrupted embayments which I have mentioned. The degradation of a crystal may be connected with planes of weak cohesion, as seems illustrated by a grain, which shows very faint, almost concentric zoning; corrosion has originated at seven or eight points along the border of the crystal, and, as it reaches successive zones, has begun to spread along them, resulting in a form like three or four shallow saucers placed one above another (Fig. 2).

Fig. 2.



(2). Orthoclase-Felsite. The hand-specimen is dull, and of a very pale chocolate-brown, with slight traces of fluidal structure. The rock is microporphyritic, crowded with felspars of definite crystalline form, which are decomposed, and contain brightly-polarizing films. From their form, and the occasional occurrence of

[1] Tsch. Min. Mitt. Bd. viii. p. 421; A. Lagorio, Abs. in Min. Mag. 1887. British Petrography, Mr. Teall, p. 407.

[2] Geol. Mag. Jan. 1888, pp. 10, 11, Lavas of Krakatoa, Prof. Judd; Pres. Address Geol. Soc. 1885, p. 54, Prof. Bonney.

[3] Q.J.G.S. 1885, p. 376, On Peridotites of Scotland.

Carlsbad twinning with simultaneous extinction, they appear to be mostly orthoclase. These felspars, and some larger crystals of a pale green hornblende, occasionally twinned, exhibit a certain orientation, which is practically the only indication of a fluidal structure seen under the microscope.

Other Igneous Rocks.—In the diorites, kaolinized felspar, and hornblende mostly in good preservation, are closely intercrystallized, with some appearance of an ophitic structure. One compact black rock occurs, which seems to be of a basaltic character. Another fragment, evidently from a lava-flow, may be a basalt, in which the augite is less clearly individualized, or it may, perhaps, be better classed with the andesites. It contains vesicles, filled up mainly with calcite, but with some chlorite; it has other calcite apparently pseudomorphic, and a zeolitic mineral seems also present. A fairly large cluster of calcite scalenohedra has been sent, and appears to have been formed in or on a greenish felsite, very decomposed fragments of which are found adhering. There is one specimen of a compact black rock, which is rather puzzling, even under the microscope; although it might be a very fine-grained igneous rock of rather basic character, yet it seems most probable that it consists of fine ashy material, with much fragmental felspar in good preservation.

Sedimentary Rocks. (1). *Argillite.*—This is a green flinty rock, with a marked and even banding. It is composed of fine material, and contains small angular fragments with a torn look, many of which are plagioclase. Except that the banding here is more evenly marked, probably in consequence of a pressure, which has acted across the lamination, this rock is very similar to those described by Prof. Bonney. It clearly bears out his suggestion, that the argillites of Socotra are probably not due to local contact metamorphism, but may represent some part of an old sedimentary series.

(2). *Grits.*—In a grit, which appears to consist mainly of fragmental felspar of more than one kind, there seems to have been a secondary deposition, probably of silica, which has remained as a cavernous skeleton, where the original grains have weathered out. Another specimen is composed, almost exclusively, of two of the constituents of a granitic rock—quartz and felspar—and is thus not unlike the Torridon sandstone of the Scotch Highlands.

(3). One specimen of a reddened limestone is very full of fragments of Gasteropod and Lamellibranch shells, the calcite of which exhibits rhombohedral cleavage, and is of a deep red colour, apparently iron-stained.

Except for a few structural characteristics, these rocks are mainly interesting as being an independent collection, which, although small, agrees closely with the description already given of Socotra rocks. The grit, here noticed, may be possibly of recent consolidation, or may belong to the sandstones, which Prof. Bonney mentions as probably present. The groups which he describes will include all the other specimens, except the fossiliferous limestone, although this might belong to the formation of the foraminiferal rock.[1] The

[1] If the limestone belongs to some other series, it might possibly be a representative of Dr. Rochebrune's Neocomians of Ouarsanguélis land.

granites, including among their constituents microcline and hornblende, the felstones, the diorites and other types of igneous rock, and the argillite, are all in close relation to the specimens already described from Socotra.[1]

IX.—Notes on the Nomenclature of the Fishes of the Old Red Sandstone of Great Britain.

By Dr. R. H. Traquair, F.R.S., F.G.S.

The nomenclature of the fishes of the Old Red Sandstone of Great Britain, with the exception of the Cephalaspidæ, revised some years ago by Professor Lankester is at present in a very unsatisfactory state. A vary large number of the species named by Agassiz, as well as by McCoy, were undoubtedly founded upon deceptive characters, due partly to different modes of preservation in different rocks, partly also to those apparent variations in external form, which are inevitable in such ancient fossil fishes devoid of a fully ossified internal framework, without which the original outline cannot be expected to be constantly preserved. In specimens from one locality the external ganoid surface of the scales may be well shown, in those from another it may be constantly hidden or obscured, while the proportional measurements in the very same species may vary infinitely, by the fish being lengthened out, or shortened up by changes, which have occurred after death or during the consolidation of the enclosing rock. These and kindred sources of fallacy can only be guarded against by long experience in deciphering such remains, coupled with the examination of an immense number of specimens.

As I am at present engaged on a complete synonymic Catalogue of the Palæozoic Ganoids and Dipnoi in the Edinburgh Museum, I shall limit myself in the following brief "notes" to indicating a few of the principal results which I have obtained in the course of my examination of the fishes of the Old Red Sandstone.

Order Dipnoi.

Family Dipteridæ (*Ctenodipterini*, Pander).

Dipterus, Sedgw. and Murch.—Four species of this genus were named by Sedgwick and Murchison, namely, *D. macropygopterus*, *D. brachypygopterus*, *D. Valenciennesii* and *D. macrolepidotus*. All four were united by Agassiz under the name of *macrolepidotus*, but it was clearly shown by Pander and McCoy that *macrolepidotus* had no place in the original definition of the genus, being possessed of rhombic instead of circular scales. The other three were maintained to be distinct by McCoy, while Sir Philip Egerton, admitting the identity of the first two, still held out for the separation of *Valenciennesii*. After a careful study of the original types in the collection of the Geological Society I fully agree with Pander that *D. macropygopterus*, *brachypygopterus*, and *Valenciennesii* are one species, for which it is desirable to retain the last-mentioned name, given in

[1] Phil. Trans. 1883, p. 273.

honour of the distinguished French ichthyologist. As a synonym it is also necessary to include *Polyphractus platycephalus*, Ag., which was long ago shown to be a *Dipterus* by H. Miller. One species, however, exceedingly distinct from *D. Valenciennesii*, may here be briefly described.

D. macropterus, n.sp. Traq.—Distinguished from *D. Valenciennesii* by the long base and broad rounded contour of the second dorsal fin, and by the thinness of the scales, which permit the outlines of the internal skeleton to be seen through them. The other fins are as in *D. Valenciennesii*, the pectorals and ventrals being beautifully "archipterygial" in their contour.

Lower Old Red Sandstone, John o'Groats, Caithness, Edinburgh Museum, collected by the late C. W. Peach.

Order Ganoidei.
Suborder Placodermata.
Family Asterolepidæ.

Asterolepis and *Pterichthys*.—There can be no doubt that *Asterolepis*, Eichwald, is prior to *Pterichthys*, Agassiz, and if Pander were right in maintaining the identity of the two genera, it would be hard to deny the preference to the first of these names. But Beyrich,[1] Lahusen,[2] and Zittel,[3] accepting Sir Philip Egerton's view that the arms in *Pterichthys* were articulated to "thoracic" plates, distinct from the anterior ventro-laterals, have founded a diagnostic mark on this supposed peculiarity, as such "thoracic" plates certainly do not exist in the Russian *Asterolepis*. But just as little do they exist in the British *Pterichthys*, as an examination of hundreds of specimens has absolutely convinced me that the pectoral limbs were articulated here precisely as in *Asterolepis*. A valid generic distinction may, however, be found in the mode of articulation of the anterior median dorsal plate. According to Pander this plate overlaps both the anterior and posterior ventro-laterals, whereas in *Pterichthys*, though it overlaps the former, it is itself overlapped by the latter. These facts regarding the body-plates of *Pterichthys* were long ago known to Hugh Miller; it is interesting to add that the general structure of *Pterichthys*, including that of the head and arms, is very much closer to that of *Asterolepis* than of *Bothriolepis*, some of whose species,—namely, *hydrophilus*, Ag., *major*, Ag., and *macrocephalus*, Egert., have been included in *Pterichthys*.

Asterolepis maximus, Ag. sp.—The large Asterolepid occurring in the Upper Old Red Sandstone of Nairn (Seabank and Kingsteps), a fragment of whose anterior median dorsal plate was figured by Agassiz as "*Coccosteus*" *maximus*, and afterwards supposed by Hugh Miller to belong to "*Pterichthys*" *major*, seems to me to be referable to *Asterolepis*, as the anterior median dorsal plate most undoubtedly overlaps both anterior and posterior dorsal-laterals. I have now got

[1] "Ueber einen Pterichthys von Gerolstein," Zeitschr. deutsch. geol. Gesellsch. 1877, p. 754.
[2] "Zur Kenntniss der Gattung *Bothriolepis*, Eichw.," Trans. Imp. Min. Soc. St. Petersburg. 1879.
[3] "Handbuch der Palæontologie," vol. iii. pt. 1, pp. 153–157.

together an instructive series of its remains, from which it appears that the head and arms closely resembled those of *Asterolepis* and *Pterichthys*, the limbs being very short, and scarcely reaching beyond the lozenge-shaped median plate of the ventral surface. As a species it is distinguished by the excessive narrowness of the anterior margin of the anterior median dorsal plate, which consequently assumes an almost pointed lanceolate contour.

Species of *Pterichthys*.—I would arrange the British species of *Pterichthys* as follows:

A. Terminal division of arm slender, tapering.
   1. *Pterichthys Milleri*, Ag. (including *P. latus*, Ag.). Inferior surface of carapace broadly ovate.
   2. *P. quadratus*, Eger. Inferior surface of carapace peculiarly short in proportion to its breadth.
   3. *P. cornutus*, Ag. (including *P. testudinarius*, Ag.). Inferior surface of carapace narrowly ovate.

B. Terminal division of arm expanded, abruptly pointed.
   4. *Pterichthys productus*, Ag. (including *P. cancriformis*, Ag.). Inferior surface of carapace narrowly ovate.
   5. *P. oblongus*, Ag. Inferior surface of carapace long and narrow, sides nearly straight.

As the distinctions of form indicated above are actual, and not the result of mere distortion by crushing, I have thought it desirable to retain the groups represented by them as distinct species. Yet so closely do they represent each other in other respects, that very possibly they may only be entitled to rank as varieties. Before coming to these conclusions, I have examined a very large number of specimens in various museums, including all the types save that of *Pterichthys quadratus*, Egert.

Before leaving the subject of *Pterichthys* I may state that I have examined the specimen in the Egerton Collection, British Museum, on which Sir P. Egerton founded his opinion that a pair of ventral fins were present in this genus, and find that the two supposed ventrals are only two portions of the dorsal separated by a little dislocation or fault, a phenomenon of by no means uncommon occurrence in nodules.

Bothriolepis, Eichwald.—When Pander wrote his well-known "Placodermen," he was unacquainted with the structure of *Bothriolepis*, else he would not have included it with *Pterichthys* as one of the synonyms of *Asterolepis*. The dorsal plate figured by Eichwald as belonging to *Bothriolepis ornatus*[1] marks it as one of a group of species, which we now know from Russia, from Great Britain, and from Canada, and whose generic distinctions both from *Asterolepis* and *Pterichthys* are of the most salient kind. Most of these distinctions were pointed out by Lahusen and by Trautschold,[2] but our knowledge of the genus has also been largely increased by the discovery of numerous well-preserved individuals of a Canadian species, which has been figured and described by Whiteaves under the name of *Pterichthys* (*Bothriolepis*) *Canadensis*.[3]

[1] Lethæa Rossica, tab. 56, fig. 3.

[2] Ueber *Bothriolepis Panderi*, Lahusen, Bull. Imp. Mosc. vol. 55, pt. 2 (1880), pp. 169-179.

[3] Trans. Roy. Soc. Canada, pp. 101-107.

In *Bothriolepis* the head plates show considerable differences of shape from those in *Pterichthys* and *Asterolepis*, the most important being the case of the postmedian, which does not extend outwards on each side to join the lateral plate, but, antero-posteriorly hemi-elliptical in contour, is received in a deep rounded notch in the median occipital. The grooves of the lateral line system are differently arranged on the head, and on the anterior median dorsal a prominent groove is seen in the form of an inverted V with the apex near the centre of the plate. The carapace is rather flattened above, and there is a longitudinal dorso-lateral as well as a ventro-lateral sharp inflexion or carina, while the arms are particularly long, sometimes extending beyond the posterior extremity of the carapace. It is odd that no trace of a scaly tail should ever have been discovered in *Bothriolepis* in spite of the perfection of numerous specimens in every other respect, but this by no means proves that the tail itself was absent, only that it had no preservable hard parts.

To *Bothriolepis* belong "*Pterichthys*" *major*, Ag., from the Upper Old Red of Scat Craig, Heads of Ayr, Siccar Point, etc.; "*Pamphractus*" *hydrophilus*, Ag., from Dura Den; "*Pterichthys*" *macrocephalus*, Egert., from Farlow, and I shall here indicate what I consider to be two additional British species.

Bothriolepis giganteus, n.sp. Traq. (= *Bothriolepis ornatus*, Ag. pars, non Eichwald).—Of large size; anterior median dorsal plate gently convex, not carinate, surface of plates covered by rather coarse tubercles more or less confluent into vermicularly contorted sometimes reticulated ridges, and frequently displaying stellate bases. Fragments of impressions of plates of this species were figured by Agassiz as belonging to *B. ornatus*, Eich. (Old Red, tab. 29, figs. 3, 4, 5), but the anterior median dorsal plate is broader in shape than that figured by Eichwald, and the sculpture is also different. Upper Old Red, Alves, near Elgin. I am greatly indebted to the Rev. Dr. Gordon of Birnie and to the Directors of the Elgin Museum for the opportunity of studying the remains of this magnificent species, of which I intend soon to give a detailed description in another place.

Bothriolepis obesus, n.sp. Traq.—Of this I have only seen the anterior median dorsal plate, posterior dorso-lateral, and the anterior and posterior ventro-laterals, the specimens being contained in the collections of the Geological Survey of Scotland, and of the Museum of Science and Art, Edinburgh. The dorsal plate is carinated along the middle line, the posterior dorso-lateral is peculiarly short and deep, the posterior ventro-lateral is remarkable for the great height of its ascending lamina, the contour of these plates indicating a carapace of a proportionally short and "thick-set" aspect. Surface coarsely tuberculated. This is also a large species, and from the Upper Old Red of Rule Water, near Jedburgh. All the British species of *Bothriolepis* are from the Upper Old Red Sandstone, and comprise the largest as well as nearly the smallest of the known forms of Asterolepidæ.

Microbrachius Dickii, n.gen. Traq. (=*Pterichthys Dickii*, C. W. Peach, name only, British Assoc. Rep. 1867, Trans. of Sections

p. 72).—Very small, head and carapace only attaining a length of 1¼ inch. Arrangement of head-plates not decipherable, carapace depressed, anterior median dorsal plate broad, overlapped by the posterior dorso-lateral, and also by the anterior dorso-lateral, except towards its anterior angles, where the condition is suddenly reversed; surface minutely tuberculated; arms very short; no trace of tail or of caudal scales. In the Museum of Science and Art, Edinburgh, collected by the late C. W. Peach, from the Lower Old Red Sandstone of John-o-Groats, Caithness.

Owing to the apparently depressed shape and the absence of caudal scales, I should have included this strange little species in *Bothriolepis*, were it not for the shortness of the arms, and the peculiar articulation of the anterior median dorsal plate. I therefore venture to propose a new genus for its reception.

Family Coccosteidæ.

Coccosteus, Agassiz.—With regard to *Coccosteus*, I believe that *C. oblongus*, Ag., *cuspidatus*, Ag., *microspondylus* and *trigonaspis*, McCoy, and *Milleri*, Eger., are all synonyms of *C. decipiens*, Ag. I rather think that *C. pusillus*, McCoy, is also a young specimen of the same species, and if so, then the name *C. minor*, Hugh Miller, should be applied to the small Thurso specimens (see Cruise of the Betsy, chap. x.) collected by Robert Dick, which most certainly are extremely distinct from the ordinary Moray Frith and Orkney examples of the genus. I cannot agree with v. Koenen in referring the specimen figured by Agassiz in his "Old Red," tab. x. fig. 1, as one of *C. decipiens*, and afterwards named by Egerton *C. Milleri*, to his new "subgenus" *Brachydeirus* (see "Beitrag zur Kenntniss der Placodermen des norddeutschen Oberdevons," Abh. Kön. Gesellsch. der Wissensch. 1883), and I may also state that among the hundreds of examples of *Coccosteus* from Scotch deposits which I have examined, I have never found the slightest trace of the pectoral spine, represented in his restoration of *Brachydeirus* (*ib.* pl. iv. fig. 1).

Homosteus, Asmuss.—As there can be no doubt that Agassiz was in error in attributing to Eichwald's *Asterolepis*, Asmuss's "Riesenknochen" from Dorpat, afterwards referred by the last-named author to two genera, *Homosteus* and *Heterosteus*, the name *Homosteus*, Asmuss, must certainly be applied to the "Asterolepis of Stromness," whose remains were first figured by Hugh Miller in his "Footprints of the Creator." As there is no evidence that this gigantic Coccostean belongs to any of these species named by Asmuss, I propose to name it *Homosteus Milleri*.

Suborder Acanthodei.
Family Acanthodidæ.

Mesacanthus, n. gen. Traq. (=*Acanthodes*, Agassiz pars).—The small *Acanthodes*-like fishes of the Scottish Lower Old Red Sandstone differ from *Acanthodes* of the Carboniferous and Permian rocks by the presence of a pair of small intermediate spines in the belly between the pectoral and ventral spines. Here may be

included *Mesacanthus pusillus*, Ag. sp., *M. Peachii*, Egert. sp. (incl. *A. coriaceus*, Egert.), and *M. Mitchelli*, Egert. sp.

Cheiracanthus, Agassiz.—In this genus a multitude of supposed species have been erected upon differences which I have for years been convinced are due merely to various conditions of preservation in different kinds of rock. As absolutely synonymous with the type species *Ch. Murchisoni*, Ag., I include *Ch. microlepidotus*, Ag., *Ch. minor*, Ag., *Ch. lateralis*, McCoy, and *Ch. pulverulentus*, McCoy. But *Ch. grandispinus*, McCoy, and *Ch. latus*, Egerton, are "good species," and are easily recognizable wherever they occur.

Diplacanthus, Agassiz.—The type of the genus, *D. striatus*, Ag., is well known to possess two dorsal spines, four pectoral, two intermediate, two ventral, and one anal. Specifically, I am unable to see any valid distinction between *D. striatus* from Cromarty and Gamrie, *D. striatulus*, Ag., from Lethen and Tynet, *D. crassispinus*, Ag., and *D. gibbus*, McCoy, from Orkney; all the distinctions which have been noted are to my mind due to differences of age and mode of preservation.

Rhadinacanthus, n. gen. Traq. (=*Diplacanthus*, Ag. pars.).—The long, slender dorsal spines of *Diplacanthus longispinus*, Ag., contrast most strongly in appearance with those of *D. striatus*, but a more obvious mark of generic distinction is seen in the absence of the second or lower pair of pectoral spines. There is a pair of intermediate ventral spines between the pectorals and ventrals. As a synonym of *Rhadinacanthus longispinus*, Ag. sp., I feel constrained to include *Diplacanthus gibbus* of McCoy.

Ischnacanthus, Powrie.—This genus, proposed by Powrie[1] for *Diplacanthus gracilis*, Eger., and afterwards withdrawn by its founder,[2] ought to be restored, as this beautiful Forfarshire species is destitute of the intermediate ventral spines with which all the other Diplacanthoid fishes are provided; the powerful dental armature of its jaws is also a well-marked feature of the genus.

Suborder Crossopterygii.

Family Holoptychiidæ.

The Holoptychiidæ emphatically differ from the other Crossopterygian families in having the pectoral fins acutely lobate; the internal skeleton of this fin must have been entirely cartilaginous, but there can be no doubt that it was a "biserial" archipterygium as in *Ceratodus*; the ventrals, however, are only subacutely lobate. The teeth are dendrodont in structure, although, as in the Rhizodontidæ, the laniaries of the mandible, except the most anterior, are set on separate internal dentary ossicles. In the Rhizodontidæ on the other hand the pectorals are subacutely or obtusely lobate, the internal skeleton of both pectoral and pelvic limbs forming an abbreviate uniserial archipterygium, and the teeth are "labyrinthodont" in structure, the dentine of the base being vertically folded in a more or less complex manner, so as to divide the pulp cavity into

[1] Quart. Journ. Geol. Soc. 1864, p. 419.
[2] Trans. Edinb. Geol. Soc. vol. i. p. 289.

a series of vertical tubes, but without the cross branches which in the dendrodont arrangement form an intricate network of vessels. Zittel, in his Handbuch, refuses to accept these families as distinct, but, adopting as a "family" the Cyclodipteridæ of Lütken, divides the genera into—

"(*a*) Unvollkommen bekannte Formen mit dendrodonten Zahnbau (*Dendrodus, Cricodus,* ? *Colonodus,* ? *Sigmodus*).

(*b*) Formen mit langgestielten Brustflossen (*Holoptychiidæ,* Traquair).

(*c*) Formen mit kurzgestielten Brustflossen (*Rhizodontidæ,* Traquair)."

Here it may be observed—

First, that there is no reason for separating *Dendrodus* from the Holoptychii, the latter being in fact "dendrodont."

Second, that *Cricodus* (= *Polyplocodus,* Pander), which he includes in his first category, is certainly not dendrodont, but Rhizodont in its tooth structure.

Third, that to include the forms with "lang-" and "kurz-gestielten Brustflossen" in one "family" is contrary to current ideas of zoologists as to the limits of such a group, indeed one might as well go back to Agassiz's plan of having "homocercal" and "heterocercal divisions" of such a so-called "family" as in his now discarded "Lepidoidei" and "Sauroidei."

The species of *Holoptychius* are extremely difficult to define, and having only a few days ago received an interesting paper from M. Lohest, of Liége, on this subject, I shall defer their consideration for the present; meanwhile I must express my opinion that the scattered teeth and fragments of jaws known as *Dendrodus* and *Lamnodus* belong to fishes at present known to us by their scales as species of *Holoptychius* and *Glyptolepis.*

The large head figured by Prof. Huxley as that of *Glyptopomus minor,* Ag., certainly belongs to *Holoptychius,* probably *H. Flemingii,* which seems sometimes to have attained a large size. The genus *Platygnathus,* Ag., also does not exist, as *Pl. Jamesoni,* Ag.—concerning which Huxley wrote that it cannot be doubted that it "is very closely allied to *Holoptychius*"—is clearly the tail end of a *Holoptychius* turned upside down, the lower aspect of the caudal being mistaken for an enormous dorsal, and the second dorsal for an anal; while the mandible from Orkney figured by Agassiz as *Platygnathus paucidens,* is with equal certainty referable to the same large species of *Glyptolepis* whose sculptured scales and dendrodont teeth were attributed by Hugh Miller to his "Asterolepis of Stromness" (*Homosteus*). This magnificent *Glyptolepis,* of which the Edinburgh Museum now possesses several entire specimens from Thurso, must therefore stand as *G. paucidens,* Ag. sp.; and as synonyms of *G. leptopterus,* Ag., I must include *Holoptychius Sedgwicki,* McCoy, and *Glyptolepis elegans,* Ag. We shall presently see that *Glyptolepis microlepidotus,* Ag., is not referable to *Glyptolepis* at all, but belongs to a different family.

Family RHIZODONTIDÆ.

The Rhizodonts are not nearly so prominent a group in the Old Red Sandstone as in the Carboniferous rocks, nevertheless their presence both in the Lower and Upper divisions of the first-named formation is attested by several well-marked genera, such as *Tristichopterus*, Egert., from the Lower Old Red of Caithness, and *Eusthenopteron*, Whiteaves, from the Upper Devonian of Canada. There are also others to which I shall now refer.

Gyroptychius, McCoy.—For many years I was much puzzled by this genus, which—originally referred to the "Cœlacanthi" by McCoy—was classed as a "Dendrodont" by Pander, and as a "Saurodipterine" by Egerton. Huxley also placed it in the rhombiferous division of his Glyptodipterini; but if Pander's figures are taken from authentic examples of *Gyroptychius angustus*, McCoy, we have to deal with a typically Rhizodont genus. Accordingly in my account of *Tristichopterus alatus* (Trans. Roy. Soc. Edin. vol. xxvii. 1875) I placed it in the group of Cyclodipteridæ (Cyclodipterini Lütk. excl. Holoptychiidæ), the family designation of which I afterwards altered to "Rhizodontidæ" (Cranial Osteology of *Rhizodopsis*, ib. vol. xxx. 1881). Not having at that time (1875) seen the original specimens, I appended a query, owing to the apparently rhombiferous squamation of *G. diplopteroides*, McCoy. Since that time a careful examination of the types in the Woodwardian Museum, Cambridge, has afforded the following explanation of the puzzle. *Gyroptychius diplopteroides* is nothing but a specimen of *Diplopterus Agassizii*, Traill (*D. borealis*, Ag.), with the ganoid surface of the scales wanting, as is so often the case in Orkney specimens, while *G. angustus* is valid generically, is a Rhizodont, and no doubt the same as the fish whose details have been figured and described by Pander. But more than this, on examining a series of specimens of *Glyptolepis microlepidotus*, Ag., including the types, I was interested to find that this fish had obtusely lobate pectorals, and labyrinthically folded tooth-bases, and is therefore not a *Glyptolepis* nor even a Holoptychian, but a Rhizodont. And on comparing those Moray Frith specimens with those from Orkney referable to McCoy's *Gyroptychius angustus*, so close is the resemblance between the rhombic diphycercal shape of the tail, the position of the fins, the shape and markings of the scales, and other details, that I am forced to the conclusion that *Glyptolepis microlepidotus*, Ag., and *Gyroptychius angustus*, McCoy, are one and the same thing. The genus *Gyroptychius* therefore stands, but *G. diplopteroides* must be cancelled, and for the type species "*microlepidotus*," Ag., must be substituted for "*angustus*," McCoy. I may remark that *Gyroptychius* is one of those genera which, like *Rhizodopsis* of the Carboniferous, closely bind together the families of Rhizodontidæ and Rhombodipteridæ.

Another Rhizodont genus of the Old Red Sandstone (Upper) is represented by the *Bothriolepis favosus* of Agassiz, a mandible of which, from Clashbennie, in the Edinburgh Museum, clearly shows that the teeth were labyrinthically folded at the base as in *Rhizodus*,

which genus it still further resembles in having the laniaries compressed and two-edged towards the apex; these laniaries are however proportionally much smaller in size, and the internal denticles which support them different in shape from those of *Rhizodus*, being broad and flat, instead of narrow and compressed. This species may probably turn out to be generically referable to *Cricodus*, Ag., which, judging from Agassiz's figures of *C. incurvus* and of *Polyplocodus* given by Pander, is certainly a Rhizodont. It will be remembered that "*Polyplocodus*" was the name by which Pander sought to displace "*Cricodus*," on the ground that the latter was descriptively inaccurate.

RHOMBODIPTERIDÆ.

It is remarkable that although Zittel, in his "Handbuch," includes the Rhizodonts in one heterogeneous family with the Holoptychii, he nevertheless keeps the Rhombodipterines apart, whose close affinity with the Rhizodonts I have indicated in my memoir on the Cranial Osteology of Rhizodopsis already quoted. In fact much is to be said in favour of Prof. Miall's plan of uniting the Rhizodonts and Rhombodipterines in one group, and in this connection I may mention the recent discovery by Mr. J. Ward, F.G.S., of a specimen apparently of *Rhizodopsis* on the scales of which there is undoubted evidence of ganoine, while I think I have myself observed the same phenomenon in the case of the fin-rays of a specimen of *Gyroptychius microlepidotus* from Tynet. But I shall for the present adhere to the arrangement given in my essay on *Tristichopterus*, thereby dividing the Rhombodipteridæ into two subfamilies—Glyptolæmini, in which the scales are sculptured and destitute of ganoine, and Saurodipterini, in which the scales are covered with a layer of ganoine and the elements of the cranial roof and of the mandible have a tendency to fusion with each other.

SAURODIPTERINI.

Osteolepis, Val. and Pentland.—The genus *Osteolepis* is mentioned by Sedgwick and Murchison as having been named by Valenciennes and Pentland with two species, *macrolepidotus* and *microlepidotus*, but, unfortunately, neither figures nor adequate descriptions are given, though Pander identifies as "*Osteolepis*" the figure given in the same paper as that of a young individual of "*Dipterus*" *macrolepidotus*. Agassiz afterwards adopted the name *Osteolepis* in place of his own "*Pleiopterus*," and described the species *macrolepidotus* and *microlepidotus* from the specimens from Orkney in the collection of Prof. Traill. Here I must agree with Pander that Agassiz's "*microlepidotus*" is identical with his *macrolepidotus*, and I feel indeed doubtful if even the latter is the same fish with that originally so named by Valenciennes and Pentland, as I have never convinced myself of its occurrence in the Caithness beds at all. And I must also agree with Pander in considering that the *Osteolepides* from the Moray Frith nodules, namely, "*arenatus*," Ag., and "*major*." Ag., are both synomymous with *O. macrolepidotus* from Orkney, and only differ in their mode of preservation. *O. brevis*, McCoy, of

which I have carefully examined the type, is, to my mind, nothing more than a shortened-up and vertically "squashed" specimen of *O. macrolepidotus.* And, as already surmised by Pander, *Triplopterus Pollexfeni*, of McCoy, is certainly an *Osteolepis macrolepidotus*, so crushed that both ventral fins are visible, one of which has been mistaken for the supposed single dorsal.

The beautiful little Caithness fish, minutely described and figured by Pander as *O. microlepidotus*, is certainly a most distinct species, whether it be that originally so named by Valenciennes and Pentland or not. It abounds in some localities near Thurso, and there is a magnificent set in the Hugh Miller Collection in the Edinburgh Museum.

Thursius, n.gen. Traq. (= *Dipterus*, Segdw. and Murch. pars, *Osteolepis*, Pander pars, *Diplopterus*, McCoy pars).—With the specimen figured by Sedgwick and Murchison as a young individual of "*Dipterus macrolepidotus*," and erroneously adopted by Agassiz as the type of the genus *Dipterus*, I identify with ease a common Thurso species, specimens of which are often seen in museums, sometimes labelled "*Osteolepis*," sometimes "*Diplopterus*." By McCoy it was considered to be a *Diplopterus*,[1] and, strangely enough, identified with Agassiz's *D. macrocephalus*, while many of the heads figured by Pander as belonging to *Osteolepis macrolepidotus* clearly belong either to this, or to a closely allied species. But in reality it belongs neither to the one nor the other genus, seeing that to the *heterocercal tail* of *Osteolepis* it adds the *opposition of the two dorsal fins to the ventral and anal respectively*, as seen in *Diplopterus* and *Megalichthys*.

Having failed in my endeavours to construct a descriptive Greek name for this genus, I have named it after the locality around which its remains are commonly found. Two species are readily distinguishable, and of these the typical one for which we are compelled to adopt the name "*macrolepidotus*" has unfortunately the smaller scales. The other, possessing scales of a remarkably large size, and having the jaws proportionally shorter and broader, I propose to call *Thursius pholidotus*. A species of the same genus, possibly distinct from the above, though closely allied to *Th. macrolepidotus*, is the most abundant fish in the flagstones of South Head, Wick, large numbers of it having been collected by the late C. W. Peach.

Diplopterus, Agassiz.—I cannot admit that there is any specific distinction between the *Diplopteri* of the Moray Frith nodules (*D. macrocephalus*, Ag., and *affinis*, Ag.) and the common Orkney species *D. Agassizii*, Traill (*O. borealis*, Ag.), nor can McCoy's *D. gracilis* be recognized as a "good" species, for reasons already frequently and sufficiently explained.

Suborder ACIPENSEROIDEI.
Family PALÆONISCIDÆ.

Cheirolepis, Agassiz.—Concerning *Cheirolepis* I have the same tale to tell. No less than six species of this genus have been described

[1] Pal. Foss. p. 587.

from Orkney and from the Moray Frith beds, namely, *Ch. Trailli*, Ag., *Ch. uragus*, Ag., *Ch. Cummingiæ*, Ag., *Ch. curtus*, McCoy, *Ch. macrocephalus*, McCoy, and *Ch. velox*, McCoy. Most patient observation has however years ago convinced me that there is only one species of *Cheirolepis* as yet known from the British Old Red Sandstone, and that all the differences noted are entirely due to different modes of preservation and crushing. A similar view was long ago expressed by Mr. Powrie (GEOL. MAG. Vol. IV. 1867, pp. 147–152).

NOTICES OF MEMOIRS.

I.—NOTE ON THE RELATION OF THE PERCENTAGE OF CARBONIC ACID IN THE ATMOSPHERE TO THE LIFE AND GROWTH OF PLANTS. By Rev. A. IRVING, D.Sc., B.A., F.C.S.[1]

THE author refers to the discussion raised recently on this question in the pages of the GEOLOGICAL MAGAZINE. In order to test the hypothesis adopted by Professor Prestwich, three series of observations have been made during the past summer on plants exposed, under similar physical conditions, to atmospheres of different compositions. The evidence obtained all points in one direction, and goes to show that, with an increase of the percentage of carbonic acid up to about that of the free oxygen present, the vigour of plant life and growth is also increased, so long as the plants are freely supplied at their roots with water, as we have good reason to suppose was the case with the vascular cryptogams from which the carbonized materials of the Coal-measures are for the most part derived. The author further considers the theory as throwing some light upon a certain stage of development of life upon the earth in later Palæozoic time; the great development of plant growth in the Carboniferous age having served as the means of storage of carbon in the earth's lithosphere, and thus purified the atmosphere so as to render it fit for the development of air-breathing forms of life in the Mesozoic age.

II.—ON THE OCCURRENCE OF IOLITE IN THE GRANITE OF COUNTY DUBLIN. By J. JOLY, M.A., B.E.[1]

IOLITE, not previously noticed in Irish granite, has been found by the author in the granite of Glencullen. It occurs as a microscopical but abundant inclusion in a substance of felspathic nature which is to be found interpenetrating prisms of beryl. Its presence is confined, apparently, to the felspar so intermixed with beryl. The iolite is in twelve-sided basal prisms, showing the faces I, i-$\breve{1}$, i-$\breve{3}$, i-$\bar{1}$, O. In size up to 0·1 mm. in length, transparent, colourless viewed singly, and presents a vivid and beautiful object in the polarizing microscope. Characteristic features are the basal angles of 150°, 120° or 60°; its generally symmetrical extinction on elongated rectangular sections and the transverse cleavage on such sections. A foliation or plating on O, and an oblique twinning-line parallel to I, are also frequently met with. Occasionally the crystals occur in radiating groups. Inclosures are rare, generally glass.

[1] Read before Section C. British Association, Bath, September, 1888.

III.—Archean Characters of the Rocks of the Nucleal Ranges of the Antilles. By Dr. Persifor Frazer.[1]

DURING a visit this year to the south-eastern part of the island of Cuba, the speaker had made some examinations of the rocks which form the nucleus of the spurs of the Sierra Maestra, and there is strong reason to believe of the axial range of the entire island and of Jamaica, Santo Domingo, Puerto Rico, and the Windward Islands as well. From the field observations there made, and an examination of the specimens under the microscope, it seems highly probable that these rocks, instead of being igneous extensions of the Tertiary period and later, are in reality of much earlier date, and may not be entirely volcanic.

The considerations which support this view are—

1. Microscopic analysis shows immense alteration to have taken place, and consequently a very long period to have elapsed.

2. The complexity of the congeries of rocks forbids the hypothesis of their having been derived from one mass. Where this congeries, therefore, is unconformably adjacent to the Tertiary, there can be no reasonable doubt that the crystalline rocks are the elder. This point of view was suggested by Mr. Teall, who would consider the argument valid also for the contact with the Cretaceous, and perhaps older series. It is difficult to see why it should not hold equally good for the contact between these crystalline and the Palæozoic rocks as made out by De Castro near Cienfuegos, etc.

3. The characters of the several associated rocks are those which one finds united in very many Archean regions throughout the world.

4. The products of alteration of these rocks are similar to those which one finds in the districts just alluded to.

5. The chemical peculiarities of the iron ores found in contact with these rocks are similar to those which one finds in the ores of the Archean regions, both in the low percentage of phosphorus and in the pyrite and (more sparingly) chalcopyrite disseminated through the ore, and in other respects.

6. If this nucleal mass had been forced up from the earth's interior in a state of igneous fusion, there would not be now (as there are) abundant traces of stratification and structure, implying an original sedimentation.

7. If this mass had resulted from volcanic outflow, there must have been contact-phenomena, and changes induced on the surfaces of the rocks with which it was brought in contact. No such contact-alteration has been observed between these rocks and either of the three groups which meet them.

8. The direction of the range, considered as a whole, lends support to the hypothesis that it is a fork of the Andes which, diverging from the main axis in Guatemala, traverses the peninsula of Yucatan, and in a symmetrical curve sweeps through the highlands of Cuba and Jamaica, Hayti, Puerto Rico, the Windward Islands, and the N.E. coast of Venezuela. This run of high land once inclosed the Caribbean as another Mediterranean Sea.

[1] Read before Section C, British Association, Bath, September, 1888.

9. The shapes of the hills of this range, produced by weathering, are not those usually visible in regions of volcanic, but rather of metamorphic rocks.

The rocks which furnished the basis for the above conclusions are all, or nearly all, alteration-products. In some cases they appeared to be the results of a second, third, or even greater number of metamorphoses, some of their constituents seeming to pass through cycles of change, ending in the mineral with which the alteration began after a number of intermediate stages. The rocks are Diorites, with Epidote, Porphyritic Dolerites, which resemble and have been taken for Syenites; Garnet rock; Actinolite; Felsite and Orthofelsite Porphyry, like that of the South Mountain of South-eastern Pennsylvania, of St. David's Head in Wales, and elsewhere. To these are added Pyrite and iron ores. Copper and manganese ores are not rare, but their relations to the rocks under consideration have not been made out.

IV.—Sur le genre *Euclastes*. By Louis Dollo. Ann. Soc. Géol. du Nord, vol. xv. (1888), pp. 114–122.

A DETAILED discussion results in the conclusion that to the synonymy of the Chelonian *Euclastes* (Cope, 1867), must be relegated the generic names *Lytoloma* (Cope, 1871), *Puppigerus* (Cope, 1871), *Glossochelys* (Seeley, 1871), *Pachyrhynchus* (Dollo, 1886), and *Erquelinnesia* (Dollo, 1887). The genus is thus defined as follows:—Skull very broad and flat. Supratemporal fossæ completely closed by a bony roof. Orbits more or less directed upwards. Nasals distinct. A lateral temporal notch well marked. Palatine expansion triangular, very thick, and almost on the level of the alveolar border. Vomer very long, extending towards the occiput, and separating the submaxillaries and the palatines for a considerable distance. Posterior nares situated much nearer the occiput than in the Chelonidæ. Palatal vacuities for the passage of the temporal muscles extraordinarily broad. Mandible massive, with a very long symphysis. Carapace rounded behind. The Chalk fossil shown in fig. 4, plate vii. A of Owen's "Mon. Foss. Rept. Cret. Form." (Mon. Pal. Soc. 1851) is considered to belong to *Euclastes;* and the genus is also represented in the Upper Cretaceous of the United States, and the Lower Eocene of Belgium and England.

V.—Sur le Crâne des Mosasauriens. By Louis Dollo. Bull. Scientifique France et Belgique, 1888, pp. 1–11, pl. i.

THE fine double plate accompanying this paper is occupied by a profile view of the skull of *Hainosaurus* and another of a less complete skull of *Mosasaurus*, each with an osteological explanation, and the two placed together for comparison. M. Dollo also investigates an interesting minute point in the osteology of the Mosasaurian skull, namely, the significance of the shallow rounded pit upon the proximal half of the quadrate bone. The feature was first noticed by Prof. E. D. Cope, who considered that it probably "received the extremity of an osseous or cartilaginous styloid stapes;" and Sir Richard Owen afterwards suggested that it might have received

"the end of a long outstanding paroccipital process, as in the Lacertilia." The discovery of the actual styloid bone in *Plioplatecarpus* leads to a different conclusion; and M. Dollo considers that the element corresponds to that termed suprastapedial by Parker, the cavity thus receiving the appropriate name of "fossette suprastapédiale."

VI.—*Iguanodontidæ et Camptonotidæ.* By Louis Dollo. Comptes Rendus, March 12th, 1888, pp. 775–777.

In 1882 Professor Marsh defined the two Dinosaurian families under discussion as follows:—

Camptonotidæ.—Clavicles absent; post-pubis complete (*Camptonotus, Hypsilophodon, Laosaurus, Nanosaurus*).

Iguanodontidæ.—Clavicles present; post-pubis incomplete (*Iguanodon, Vectisaurus*).

In the same year, M. Dollo attempted to show that the supposed clavicles were really sternal bones, and proposed a rearrangement thus:—

Hypsilophodontidæ.—Four functional toes. Sternum consisting of a simple rhomboidal bony plate (*Hypsilophodon*).

Iguanodontidæ.—Three functional toes. Sternum consisting of two bony plates, one left and one right (*Camptonotus, Iguanodon, Laosaurus, Nanosaurus, Vectisaurus*).

A reconsideration of the subject now induces the Belgian Palæontologist to return to Professor Marsh's original arrangement, with amended definitions, thus:—

Camptonotidæ.—Premaxillæ toothed. Sternum unpaired, manus morphologically pentadactyle, and reduced on the ulnar border and in the centripetal direction. Thumb normal. Ossification of the pubis extending to the extremity of the ischium. Fourth trochanter pendent. Four functional pes-digits.

(*a*.) Two phalanges in manus-digit v. Preacetabular process of the ilium slight. No rudiment of pes-digit v. (*Camptonotus.*)

(*b*.) No phalange in manus-digit v. Preacetabular process of the ilium long. A rudiment of pes-digit v. (*Hypsilophodon.*)

Iguanodontidæ. — Premaxillæ edentulous. Sternum paired. Manus morphologically pentadactyle, and reduced on the radial border and in the centrifugal direction. Digit v. normal. Pubis only extending to the distal extremity of the ischium in a ligamentous state. Fourth trochanter crest-like. Three functional pes-digits. (*Iguanodon.*) A.S.W.

VII.—List of Fossil Mammalia. By Dr. Otto Roger. Bericht Naturw. Vereins Schwaben u. Neuburg in Augsburg, vol. xxix. (1887), pp. 1–162.

This important work of reference is a new edition of Dr. Roger's list of known fossil mammalia published in the Correspondenz-blatt Regensburg. zool.-min. Verein, 1879–82. It incorporates the recent results of Schlosser, Lydekker, Trouessart, and the American palæontologists, and is thus brought well up to date.

REVIEWS.

I.—Some Devonian and Silurian Fossils of North America. By James Hall and J. M. Clarke.

IN continuation of the grand series of monographs on the Natural History of the State of New York, prepared by eminent naturalists and geologists, and issued from time to time at the expense of the State, we have lately received a handsome instalment. This is a thick quarto volume, entitled :—

"Geological Survey of the State of New York. Palæontology: Vol. VII. Text and Plates. Containing descriptions of the Trilobites and other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung, and Catskill Groups. By James Hall, State Geologist and Palæontologist. Assisted by John M. Clarke." 4to. lxiv. and 236 pages, and 45 plates. Together with a "Supplement to Vol. V. Part 2, of the Palæontology of New-York State. Pteropoda, Cephalopoda, and Annelida;" 42 pages, and plates 114 to 129. Albany, N. Y., 1888.

This is a most valuable contribution to our knowledge of the palæontology, chiefly of the Devonian rocks of the State of New York; and is a large addition to the extensive series of State publications. which the veteran Professor Hall has already produced in Albany, N.Y., with the aid of the State Museum of Natural History. In the preparation of the important volume before us, Dr. James Hall states, in the preface, that he has to acknowledge with great satisfaction the able and untiring efforts of his Assistant, Mr. John M. Clarke, both in the preparation of the matter for the press, and in the critical study of the material. With such fossils Mr. Clarke's long-continued researches have made him well acquainted, as shown to a great extent by his previous memoirs.

A study of the descriptions and figures of the Trilobites, forming the first 152 pages and 34 plates, particularly impress us with the fact of a close similarity of the North-American Devonian forms to those of Europe. Many of the genera, as *Calymene, Homalonotus, Phacops, Dalmanites, Lichas,* and *Proëtus* suggest to some extent an Upper-Silurian facies, as found in this country ; and some, as *Phacops* and certain forms of *Proëtus,* seem to be closely related to the Devonian species of the Eifel.

Attention is arrested by such species here figured as *Dalmanites regalis,* in which the front border is ornamented with a symmetrical denticulation, consisting of distinct, subquadrate, tooth-like processes, resembling the cog-wheels of a clock. These are shown in *Dalmanites Ægeria* to have united one to the other along the outer margin, leaving hollows between their bases. Such a structure is seen also in *Trinucleus,* as figured and explained by the late J. W. Salter and Dr. H. Woodward.

Some of the figures given of *Homalonotus, Dalmanites,* and *Lichas* admirably convey the idea of the great size attained by several of the species, and of the rich and grotesque ornamentation frequently present.

Three plates and ten pages of description are given to the Limulidæ and Eurypteridæ. The former has but a poor representative (*Protolimulus Eriensis*). Of the latter, *Stylonurus excelsior*, known by a perfect head-shield and portions of its maxillipeds, was a veritable giant among Devonian Crustacea, and is well figured in two large plates. Other smaller Eurypterids are described and figured. The *Equisetides Wrightianus* is here referred to *Stylonurus*; for that genus, however, the three body-segments preserved appear to be too slender and cylindrical (see GEOL. MAG. 1884, p. 395). We may venture also to suggest that *Eurypterus Beecheri*, with its long slender swimming feet, may really belong to the genus *Stylonurus* (see GEOL. MAG. 1888, p. 420).

Under the PHYLLOCARIDA are given—(1) The Ceratiocaridæ, with *Ceratiocaris* (3 species), *Echinocaris* (7 species), *Elymocaris* (2 species), *Tropidocaris* (3 species); (2) the Pinocaridæ, with *Mesothyra* (4 species), *Dithyrocaris* (1 species); (3) the Rhinocaridæ, with *Rhinocaris* (2 species); the Discinocaridæ, with *Spathiocaris* (1 species), and *Dipterocaris* (3 species). Under the PHYLLOPODA we find *Estheria* and *Schizodiscus*, of the Limnadiadæ, each with one species.

Of the species here described ten have been already published by Mr. J. M. Clarke, and he now adds seven new species. The genera *Mesothyra*, *Rhinocaris*, and *Schizodiscus* are also newly proposed by Mr. Clarke. Of the other Phyllocarids most have been described by Messrs. Whitfield and Beecher. These interesting, but little-known, Devonian Phyllocarids are here conveniently brought together in eight excellent plates, with forty-seven pages of description.

Before leaving the Crustacea, we find twelve pages and one plate devoted to the Devonian Cirripedia of the district under notice. The most remarkable forms here described belong to the Balanidæ, a division of the group not heretofore noticed in strata earlier than the Chalk formation in England, and the Carboniferous of Saxony. Two forms of these sessile Cirripeds (*Protobalanus*, Whitfield, and *Palæocreusa*, Clarke) are figured and described. The latter is found imbedded in *Favosites*, just as similar living forms are parasitic in Corals.

A new genus of Lepadidæ (*Strobilepis*, J.M.C.), characterized by spinous and delicately punctate valves, is figured and described; also eight species of *Turrilepas*, founded on detached valves. There may be a doubt as to the specific distinctness of some of these latter, seeing that in the groups of Lepadidal valves found together in England several rows of differently shaped valves are associated in the test of one individual. Mr. Clarke has evidently noticed this condition to a considerable extent in the American forms among the detached valves.

The Supplement of Vol. V. follows the above-mentioned Vol. VII., with an account of various Silurian Pteropods, Annelids, and Cephalopods. *Tentaculites*, *Hyolithes*, *Styliola*, *Coleolus*, and *Pharetella*, as Pteropoda, take 3 pages and 1 plate. The Tubicolar Annelids, with 15 pages and three plates, are all grouped as *Cornulites*.

One of the plates especially gives the development of the *Cornulites* of the Hudson-River group in various stages of growth.

In thirteen fine plates and sixteen pages of text several species of *Orthoceras, Gomphoceras, Cyrtoceras, Gyroceras, Nautilus,* and *Goniatites* from the Palæozoic rocks of North America, are well treated as part of the Supplement to Vol. V.

In the Preface Prof. Hall briefly gives the history of the volume before us, and of the material and plates still remaining on hand for want of funds necessary for the publication, and acknowledges the liberality of many friends and Institutions in having lent him specimens for study and comparison.

In the Introduction a bibliographic history, a classified list, and a chronological or stratigraphical distribution of the Devonian Trilobites and other Crustacea of North America are concisely given. A synopsis of the genera, with synonyms and sketches of types, form a very useful part of the Introduction. Our readers will thus see that Geologists, both at home and abroad, will greatly profit by the labours of Prof. Hall and Mr. Clarke in the Albany Museum; and it is hoped that the State of New York will be able to make the requisite appropriations for the furtherance of Prof. Hall's earnest desire to work out a complete exposition of the Fossils of the State, and to finish the revision of such as in his opinion require renewed criticism.

II.—Dr. Anton Fritsch on *Ctenodus* and other Palæozoic Dipnoan Fishes.[1]

DR. FRITSCH'S great work upon the Permian Vertebrata of Bohemia has now progressed as far as the fishes, and the new part just issued treats of the interesting Dipnoan genus *Ctenodus*. As in the previous parts, devoted to higher Vertebrates, the text is accompanied by numerous woodcuts, in addition to the beautifully executed plates; and every known fossil throwing light upon the subject is amply discussed, no less than ten of the figures representing specimens that are not Bohemian, and six being devoted to important features in the skeletal anatomy of the living *Ceratodus*.

The Professor commences by emphasizing the intimate relationship existing between the genera *Ctenodus* and *Ceratodus*, and continues the introductory remarks by some brief reference to *Megapleuron, Conchopoma,* and *Phaneropleuron,* which he also considers to be close allies. An examination of the type-specimen of *Megapleuron* has convinced Dr. Fritsch that its supposed rhombic scales are truly those of a Palæoniscid mingled with the skeleton—a conclusion which the writer of this notice has also been able to confirm; and doubts are expressed as to whether Kner may not have been misled by a similar accident, when he assigned rhombic scales to *Conchopoma*. The latter is a more uncertain case; the scales of *Conchopoma* are small, thin, and striated; and the suggestion that the teeth of

[1] Anton Fritsch, "Fauna der Gaskohle und der Kalksteine der Permformation Böhmens," Band ii. Heft 3 ("Die Lurchfische, Dipnoi, nebst Bemerkungen über silurische und devonische Lurchfische"), pp. 65—92, pls. 71—80. (Prag, 1888.)

this genus may eventually prove to be so arranged as to appear the homologues of the dental cusps of *Ctenodus tuberculatus* has also still to be substantiated by future discoveries.

Ctenodus is defined as "a Dipnoan of *Ceratodus*-like structure. Dental plates with many notched ridges. Dermal bones of the head more numerous than in *Ceratodus*. The hyoid and the entire skull more elongated than in *Ceratodus*. The skeleton more completely ossified than in *Ceratodus*, but otherwise agreeing with the latter in detail. Scales large, thin, of elongated quadrangular form, bearing traces of fine rows of denticles; with vascular grooves on the under side." All the portions of the skeleton are then described under the heading of *Ctenodus obliquus*, Hancock and Atthey, it being quite impossible to separate the bones of a second species (*C. applanatus*, Fritsch) that also occurs at Kounová. The more important fossils were obtained from the pyritous shales in the latter locality; and it is disappointing to read that Dr. Fritsch's admirable galvanoplast reproductions of the Stegocephalians met with so few purchasers, that it has been deemed impracticable to secure permanent copies of these new destructible Ichthyolites by the same costly process.

In the skull of *Ctenodus* there are several ossifications in parts that remain permanently cartilaginous in *Ceratodus*; and many interesting comparisons are made. A bone that was formerly described as the pelvis of a Stegocephalian, is now recognized as the squamosal of *Ctenodus*. The cranial roof bones appear to defy all attempts at definite nomenclature; and there is no distinct evidence of ossified maxillæ and premaxillæ. The opercular bones, with the exception of the operculum itself, are also not yet capable of certain determination. With regard to the mandible, Dr. Fritsch identifies a small fossil with the thin plate described by Huxley in *Ceratodus* as the dentary element; and a figure is given to illustrate the insignificant dimensions of this bone, and the importance of its claims to recognition as a peculiar "dermomental" element. The small development of the dentary bone, however, in certain Mesozoic Ganoids with crushing teeth (e.g. Pycnodonts and *Belonostomus*), seems to render the original determination quite as plausible as that now suggested by Dr. Fritsch.

The teeth referred to *C. obliquus* in the present monograph were at first made known by Dr. Fritsch under the name of *Ceratodus Barrandei*; and an interesting series is figured to show the changes that appear to take place in the dentition during the growth of the fish. The Professor remarks:—"We possess a series of the teeth, from 11 to 54 mm. in length, and there is really no doubt that these belong to different stages in the life-history of a single species. They are two and a half times as long as broad, and the number of notched ribs varies from 7 to 9. The most anterior seven ribs are especially prominent, but the eighth and ninth are at times indistinct, and then follow two or three small tubercles, which represent additional crimped ribs. The ribs decrease in length backwards, so that the seventh is only half as long as the first. The crimping is mostly

indistinct on the first rib, and, notwithstanding the difference in the length of the ribs, the others all have an equal number of outwardly directed cusps. The smallest examples exhibit five cusps on each rib, the largest, seven to nine. In very old teeth, the inner crimpings become indistinct. With increasing age, also, the dental plate becomes arched; while the smallest young teeth are comparatively flat, the largest old examples appear arched above, as shown by a comparison of the profile figures. The small dental plates correspond to those that have been named *C. elegans*, H. and Atth., in England; the large ones agree with *C. obliquus*, H. and Atth." No vomerine teeth have hitherto been detected in Bohemia, and figures only of an English specimen are thus given. Some remarks are made upon the microscopical structure of the teeth, with illustrative drawings of sections; and it is pointed out that in the vasodentine of *Ctenodus* the vessels are more branched and anastomosing than in *Ceratodus*.

Proceeding to a discussion of the axial skeleton of the trunk, Dr. Fritsch considers that there is evidence again of an extremely close approximation to *Ceratodus*. The notochord seems to have been persistent, with slight ossifications in the sheath; and the first rib is considered to have been relatively very stout, as in the existing genus. Many of the ribs show traces of having been broken and repaired during life.

The brief sections upon the appendicular skeleton bear witness once more to the laborious and exhaustive character of the investigations made by Dr. Fritsch in regard to the most unpromising fragments. None but isolated bones of the limbs and their supporting arches have hitherto been discovered; but an attempt is made to restore the pectoral arch—consisting of a greater number of elements than that of *Ceratodus*; and again, attention is directed to the high degree of ossification of all the parts.

The last plate is devoted to an interesting comparison of the scales with those of *Ceratodus*. The outer side of each scale "appears smooth in the middle, and is only seen to be rugose when highly magnified. The border exhibits concentric lines of growth, of varying width, parallel to the margin. Across these extend small parallel ridges, on the middle of which are rows of minute pits, apparently indicating the spots that originally supported denticles." Another noteworthy feature is the forked appearance of the sensory canal upon a detached scale of the lateral line—a condition unknown in *Ceratodus*.

As the result of his researches, Dr. Fritsch considers that the Bohemian examples of *Ctenodus obliquus* must have attained a length of about 140 centimetres. "The greater number of the dermal bones in the skull, added especially to the stronger ossification of the entire skeleton than in the case in *Ceratodus*, parallels what we have observed among the Permian Amphibia, which also have the skull better armoured than their now living allies."

Ctenodus applanatus, Fritsch, is defined as having flattened upper teeth, only twice as long as broad, with sharp but scarcely crenated

ridges; and a new species, *C. trachylepis*, is founded upon detached scales from Nyřan.

The concluding section of the Monograph relates to some fragmentary evidence of Dipnoan fishes from the Silurian and Devonian formations. A new genus and species, *Dipnoites Perneri*, is indicated by a supposed head-bone from the Upper Silurian (Stage G. 3) of the neighbourhood of Prague. A new and more satisfactory figure of the type-specimen of *Gompholepis Panderi*, Barrande, is next given; and this, too, is regarded as a dermal bone of the cranial roof of a Dipnoan—an interesting bone of *Ctenodus* being figured for comparison. Dr. Fritsch adopts Traquair's determination of the Dipnoan character of *Palædaphus*, and claims to have arrived at the conclusion independently; he then adds a new figure of *Phyllolepis concentricus*, Agass., considering this fossil as probably the head-bone of a closely-allied fish; and *Archæonectes pertusus*, H. von Meyer, and *Holodus Kiprijanovi*, Pander, are finally briefly noticed, the type-specimen of the former being regarded as the bony portion of the palate, wanting the teeth.

Dr. Fritsch appends a synopsis of the literature of the subject (in which we miss a reference to two important papers by W. J. Barkas, in the Proc. Roy. Soc. N. S. Wales, 1876-7); and a list of the known genera of Palæozoic Dipnoan Fishes is given as follows:—

SILURIAN.—*Gompholepis*, Barrande, *Dipnoites*, Fritsch.

DEVONIAN.—*Palædaphus*, Van Beneden and de Koninck; *Phyllolepis*, Agassiz; *Archæonectes*, H. von Meyer; *Holodus*, Pander; *Conchodus*, McCoy; *Mylostoma*, Newberry.

CARBONIFEROUS AND PERMIAN.—*Megapleuron*, Gaudry; *Campylopleuron*, Huxley; *Conchopoma*, Kner; *Phaneropleuron*, Huxley; *Ctenodus*, Agassiz; *Ptyonodus*, Cope; *Gnathorhiza*, Cope.

The genus *Strigilina*, Cope, is also added, but we would remark that that has already proved to be founded upon a tooth of *Janassa*.

It is fortunate for Vertebrate Palæontology that the Bohemian fossils have fallen into the hands of so painstaking an investigator as Dr. Fritsch; and we eagerly await the appearance of the remaining parts of this great work, which will treat of ichthyolites of a still more satisfactory character than those now described under *Ctenodus*.

A. S. W.

REPORTS AND PROCEEDINGS.

THE INTERNATIONAL GEOLOGICAL CONGRESS.

Rarely, if ever, has so large a number of distinguished geologists been drawn together as were assembled in the University of London on the opening of the fourth session of the International Geological Congress on the 17th of September. The presidential address by Professor Prestwich, delivered in faultless French, traced in brief the history of the Congress and forecast its future work. After the delivery of this address in the theatre of the University, the members were received by Prof. and Mrs. Prestwich in the Library,

which had been transformed, by the exertions of Dr. Hinde and a few fellow-workers, into a temporary geological museum. This museum remained open during the week, and proved a permanent centre of attraction, while its value was increased by the publication of an excellent Catalogue, copies of which were distributed among the members.

On Tuesday morning the discussions were centred on the classification of the Cambro-Silurian strata. The general opinion was decidedly in favour of recognizing three divisions. Mr. Marr suggested that the three groups should be united under the name of *Barrandian.* Dr. Hicks and some other speakers advocated the use of Prof. Lapworth's term *Ordovician* for the group of strata intermediate between the Cambrian and Silurian; but this compromise, though offered in a spirit of conciliation, was not generally accepted. No votes were taken at this or at any other meeting, but the discussions were nevertheless of value in that they served to elicit the feeling of the principal members. The method of voting followed at previous meetings has been revised, so as to avoid in future any undue advantage being enjoyed by the country in which the Congress is assembled.

The sittings on Wednesday and Thursday mornings were occupied mainly with the discussion of questions bearing on the nature and origin of the crystalline schists. A number of valuable contributions from foreign geologists had been printed in advance and circulated among the members; but in compliment to our guests the views of British geologists were excluded from this volume. A paper by Dr. Reusch, dealing with the crystalline schists of Norway, was received too late for insertion, but will appear in the final Report.

One of the most useful efforts of the Congress is directed to the preparation of an International Geological Map of Europe on a scale of 1 : 1,500,000. M. Hauchecorne submitted to the meeting specimens of the first sheet of this map. It had been printed at Berlin in the colours recommended by the Map Committee of the Congress, the general principle followed in the colouring being that the older the formation, the deeper is the colour. The effect of the map was eminently satisfactory, and though some of the colours differ widely from those employed for corresponding formations in this country, it received general commendation.

Excursions were organized during the week to Crayford under Mr. Whitaker, and to Windsor with Mr. Drew and Dr. Carpenter. Visits were made to both sections of the British Museum, one under the direction of Mr. Franks, the other under Prof. Flower; and to Kew Gardens with Mr. Thiselton Dyer. In the evenings receptions of a brilliant character were held by the Director-General of the Geological Survey and by the President of the Geological Society.

On the conclusion of the week's work the members dispersed in various directions, most of them taking part in excursions which had been organized, under competent leaders, to North Wales, East and West Yorkshire, East-Anglia, and the Isle of Wight. The Ex-

cursion Guide-book, edited by Mr. Topley, formed a thick volume illustrated by coloured maps and by numerous sections. It is to be regretted that the cost of printing the literature, which was freely distributed, and other expenses incidental to the meeting, have been heavier than was anticipated, and it remains to be determined how the cost of issuing the final Report is to be met.

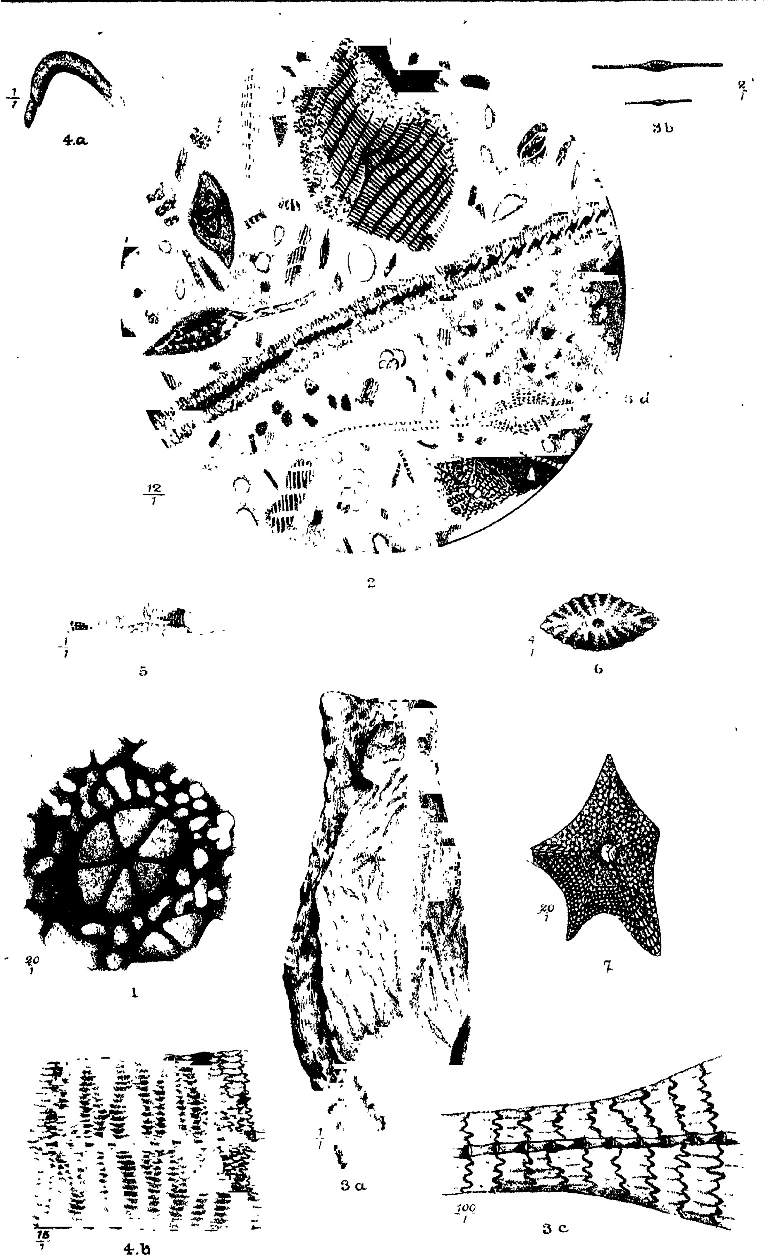
OCCURRENCE OF A TOOTH OF THE BLUE SHARK (*CARCHARIAS GLAUCUS*) IN THE BRICK-EARTH OF CRAYFORD, KENT.

SIR,—I have lately received from a member of the Geologists' Association, Mr. Henry E. Jones, of Ealing, an interesting Selachian tooth from the Thames Brick-earth at Crayford, Kent. The specimen was discovered by Mr. Jones himself in the well-known pit from which the numerous Mammalian remains are obtained; and its mineral condition is such as to leave no doubt that it is a true Pleistocene fossil. The tooth may be assigned without much hesitation to the symphysial region of the lower jaw of an adult Blue Shark (*Carcharias glaucus*), about 8ft. in length; and the fact that it is merely a hollow germ, and yet unbroken, shows that it cannot have been subjected to much rough usage before entombment. Many of the Selachian remains of Pliocene deposits are practically indistinguishable from the corresponding parts of living species still inhabiting the Northern Hemisphere; and it is natural to expect that similar forms will be found in beds of Pleistocene age. At present, however, we are only acquainted with evidence of *Galeus canis*, *Acanthias vulgaris*, *Raja batis*, and *Raja clavata*, described by Mr. E. T. Newton from the Forest Bed Series of Norfolk; and the new Crayford discovery is still more interesting on account of the distance of the locality from the existing coast-line.

ARTHUR SMITH WOODWARD.

We learn that Professor J. W. Spencer, M.A., Ph.D., F.G.S. (late of the University of Missouri), who has contributed several papers to this Journal upon Glacial phenomena in Europe and America, has recently been called to the Chair of Geology in the University of Georgia, Athens, Georgia, U.S.A.

ERRATUM.—In the October Number on page 434, line 27 from top of page, for "*exo*podite" read *endo*podite."



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Orbitoidal Limestone of North Borneo

THE

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ORIGINAL ARTICLES.

I.—NOTE ON THE ORBITOIDAL LIMESTONE OF NORTH BORNEO.

By A. VAUGHAN JENNINGS, F.L.S.,
Assistant in the Geological Department Normal School of Science and Royal School of Mines.

(PLATE XIV.)

THE specimens which form the subject of the present note were brought to England by Mr. H. T. Burls, A.R.S.M., F.G.S., late Geologist to Rajah Brooke, of Borneo.

It was Mr. Burls's intention to communicate to the GEOLOGICAL MAGAZINE the results of his observations in North Borneo, and in this connection I undertook the examination of the limestone with a view to obtaining evidence as to its age. On his departure for South Africa, Mr. Burls left the specimens at the Science Schools, asking me to make what I could out of them without stratigraphical details.

Under these circumstances the present communication has only the value of adding a few particulars to our knowledge of one of those limestones in the Dutch East Indies which have been loosely grouped together as Nummulitic.

The rock is a hard, compact, partly crystalline limestone, with specks of iron oxide and thin streaks of calcite, showing little trace of organic structure on a freshly broken surface, and altogether one that from its physical characters might readily be supposed to come from a formation of much earlier date.

Two specimens, which I understand to be from Silungen in Soubis, are of a brown colour, and differ from the others in the species of *Orbitoides* that form their chief organic constituent.

The remainder from Batu Gading, a locality considerably further inland, to the south, are pale grey in colour, and, where partly polished by the action of running water (having been collected in a stream-bed), show sections of thin *Orbitoides* discs in great numbers.

Under the microscope both rocks are seen to consist of a granular calcareous ground-mass, in which numerous more or less perfect organic remains, chiefly of Foraminifera, are embedded (Pl. XIV. Fig. 2). These and the cracks and interspaces of the rock are filled in with crystalline calcite.

After boiling in acid an insoluble residue is left, consisting of fine argillaceous material, with a considerable number of minute quartz

crystals. The only organic body observed in the residue was a fragment of a hexactinellid sponge.

The Foraminifera, so far as they can be identified with any certainty in section, are *Miliola*, *Nodosaria*, *Textularia*, *Globigerina*, *Amphistegina*, *Heterostegina*, and *Orbitoides*. The naming of Foraminifera which lie in a hard rock at all angles to the plane of section is unsatisfactory work at best, and I must trust to the accompanying figures to justify my identifications (see Plate XIV.).

The difficulty is still greater in the discrimination of species of *Orbitoides*, and in this case I have attempted determination only in the case of approximately median sections. Moreover, the study of this genus, comparatively simple in the days when only two types were recognized, has become a matter of considerable trouble since the researches of Dr. Gümbel [1] have raised the number of species to over twenty, necessitating in his opinion the establishment of five subgenera.

Orbitoides from N. Borneo.

O. (*Discocyclina*) *papyracea*, Boubée, sp.,[2] Pl. XIV. Fig. 5.

Some large forms occurring in the Silungen limestone appear to belong to this widely distributed and variable species, the *O. Fortisii* and *O. Pratti* of English writers. Dr. H. B. Brady [3] has recorded it from Sumatra, and it is common in the Nummulitic formation of Scinde.

O. (*Discocyclina*) *ephippium*, Sow. sp.,[4] Pl. XIV. Fig. 4*a*, *b*.

To this species, which has a similar structure to that of *O. papyracea*, but differs from it in its saddle-shaped curvature, I have referred several forms in the Silungen limestone. They are larger and thicker than those figured by Gümbel from the Alpine Eocene, and by Dr. K .von Fritsch from Borneo,[5] but not more so than the original type. In the several examples in the Borneo limestone the symmetry of the curvature, together with the absence of intermediate forms, prevents one from regarding them simply as abnormally grown individuals of *O. papyracea*. The species is well known from the Scinde formation.

O. (*Discocyclina*) *dispansa*, Sow. sp.,[6] Pl. XIV. Fig. 6.

Small thick lenticular forms, with large embryonic chambers and thick columns, corresponding to a marked surface tuberculation, seem to be without doubt referable to this species. The examples are similar in shape to those recorded by Dr. Brady from Sumatra,[7] while those figured by Dr. K. von Fritsch from Borneo are of the variety with wider disc. The species is also common in the Scinde formation.

[1] Abh. d. k. bayer. Akad. Wissenschaft., München, Bd. x. Abth. 2, pp. 501–730, Taf. 1-4 (4to.), 1868.
[2] Bull. Soc. Géol. France, vol. ii. 1832, p. 445.
[3] Geol. Mag. Vol. II. 1875, p. 535, Pl. XIV. Fig. 1.
[4] Trans. Geol. Soc. ser. 2, vol. v. 1840, Explan. pl. 24, fig. 15.
[5] Palæontographica, 1878, Supp. iii.
[6] *Op. cit.* p. 327, pl. 24, figs. 15, 16.
[7] *Op. cit.* p. 536, pl. 14, fig. 2.

O. (*Discocyclina*) *applanata*, Gümbel.,[1] Pl. XIV. Fig. 3*a*, *b*, *c*, *d*.

While the Silungen limestone contains the thicker, more lenticular forms mentioned above, the specimens from Batu Gading are full of a thin, discoid, umbonate species apparently the *O. applanata* of Gümbel. In vertical section they are seen to possess a median plane of rectangular chambers, and only three or four layers of lateral chambers on each side, except at the central umbo. The solid columns are not prominent. Numerous horizontal sections evidently of the same form show that the chambers of the median plane are rectangular and narrow, the radial measurement often four times the tangential. This character, together with the shape, would seem to decide its position in this species. Gümbel mentions its occurrence in Scinde.

O. (*Asterocyclina*) *stellata*, Gümbel.[2] Pl. XIV. Fig. 7.

The stellate *Orbitoides* included by Dr. Gümbel in this subgenus have a sufficiently characteristic appearance when cut horizontally to admit of recognition even in a rock section. One of them occurs in the Batu Gading limestone, and is apparently a young form of this species.

O. (*Lepidocyclina*) *Mantelli*, so abundant elsewhere, does not appear to be present, nor any of the *Rhipidocycline* species. There are several small thick forms of the size of *O. Sumatrensis*, Brady,[3] but they have large embryonic chambers, and seem to be young forms of other species.

Nummulites itself seems to be absent.

The only other fossil is a coral in the Silungen limestone, which Prof. P. Martin Duncan has kindly examined, and refers to the genus *Stylophora* (Pl. XIV. Fig. 1). As this is a common type throughout the Tertiary rocks, its occurrence is of little stratigraphical value.

With regard to the age of the Orbitoidal limestone, there is little to be said until more is known of its position and stratigraphical relations.

The limestones and associated beds of Java have been doubtfully regarded as Eocene, an opinion supported by the resemblance of their Molluscan fauna to that of the older European Tertiaries. According to von Richthofen,[4] however, the associated plant-remains pointed distinctly to their being at the oldest Miocene, and this view was supported by the discovery that what had been taken for Nummulites were Orbitoides, and by the suggestion, so strongly enforced by Dr. Duncan's examination of the Scindian Corals,[5] that parts of the Indian 'Nummulitic' formation were probably Miocene. It is worth noticing also that in Sumatra[6] the Orbitoidal limestone occurs at the top of a series of Tertiary beds.

1 *Op. cit.* p. 122, pl. 3, figs. 17, 18, 35, 36, 37.
2 *Op. cit.* p. 135, pl. 2, fig. 115; pl. 4, figs. 4–7.
3 *Op. cit.* p. 536, pl. 14, fig. 3.
4 See H. M. Jenkins' Summary, Q.J.G.S. vol. xx. 1864, pp. 62–72.
5 See Palæontologia Indica, ser. xiv. vol. i. pt. i. Sind Fossil Corals, 1880, pp. 3–14.
6 Verbeek, Geol. Mag. 1875, p. 479.

The specimens now under consideration do not affect the question decidedly either way. The fact that all the forms mentioned above occur in the European Eocene would appear to be an argument in favour of the Eocene age of the rock. The Eocene facies of the Foraminiferal fauna may, however, be due to that eastward migration which appears to have taken place, and which may account for the character of the mollusca in strata that would otherwise be looked upon as Miocene.

Amphistegina and *Heterostegina* are rather Miocene than Eocene genera, and in an Eocene limestone of this kind one would expect to find Nummulites associated with the Orbitoides.

Dr. K. von Fritsch's *Patellina trochus* from Borneo[1] very probably comes from beds below the limestone, and in its form and size it seems identical with the small pointed forms occurring in the Cretaceous of Navarre. The large fossil *Patellinæ* have been regarded as characteristic of the Cretaceous and Eocene, but they undoubtedly range above the Eocene, and specimens in the Science Schools Collection from the Miocene of Jamaica occur associated with *Orbitoides*, *Amphistegina*, and *Heterostegina*.

On the whole, therefore, though the species of *Orbitoides* are among those which characterize the Eocene rocks in Europe, there is good reason for defending the suggestion that the Orbitoidal Limestone of Borneo may be of a later date.

The work on these specimens has been done in the Geological Laboratory of the Normal School of Science and Royal School of Mines, and I have to thank Professor Judd, F.R.S., for the facilities afforded me in the preparation of sections, etc.

EXPLANATION OF PLATE XIV.

Figures of Orbitoidal Limestone of North Borneo.

Fig. 1. *Stylophora*, sp. × 20.

Fig. 2. Section of the Limestone of the Batu Gading, showing *Miliola*, *Nodosaria*, *Textularia*, *Amphistegina*, *Heterostegina*, and *Orbitoides applanata*, Gümbel × 12.

Fig. 3. *O. (Discocyclina) applanata*, Gümbel.
- *a.* As seen in the water-polished surface of rock.
- *b.* In vertical section × 2.
- *c.* ,, ,, × 100.
- *d.* ,, ,, × 12.

Fig. 4. *a.* *O. (Discocyclina) ephippium*, Sow. sp.
- *b.* In section × 15.

Fig. 5. *O. (Discocyclina) papyracea*, Boubée, sp.

Fig. 6. *O. (Discocyclina) dispansa*, Sow. sp.

Fig. 7. *O. (Asterocyclina), stellata*, Gümbel.

II.—On the Genus *Ascoceras*, Barrande.

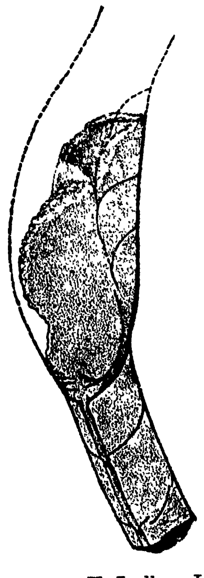
By Professor G. Lindström, of Stockholm.

THE uppermost limestone stratum of Gotland, which occupies two-thirds of the surface of this island, and is homotaxial with the English Upper Ludlow, contains such numerous fragments of Cephalopoda, that it has been called the Cephalopodan Limestone. Judging from the collection in the Palæontological Depart-

[1] *Op. cit.* p. 145.

ment of the Swedish State Museum, the number of species of Cephalopoda from the different strata of Gotland can hardly fall short of 200, most of them in a very perfect state of preservation, some even retaining the surface ornamentation and colour. Amongst them the genus *Ascoceras* (including *Glossoceras*), with its nine species, is the most remarkable. As the Museum has succeeded in obtaining specimens showing its morphology more completely than has hitherto been known, a few remarks on it may be made in advance of a monograph now in preparation.

The annexed figure represents a longitudinal section of a specimen from the uppermost limestone. It is imperfect on the ventral side, but the characteristic septa along the dorsal side show distinctly that it is an *Ascoceras*. We see here two essentially different parts of the shell: *first*, a lower part in which two entire air-chambers and a portion of a third yet remain, which are fashioned, after the common Nautilidean type. The *second* or upper portion in immediate continuation and connexion with the former, is the *Ascoceras* properly so called. The entire shell must have been arcuate or gently curved, like some forms of *Cyrtoceras*, but it is doubtful if complete specimens ever existed, since several examples clearly show that the older parts of the shell were, at certain intervals, regularly cast off or decollated. The truncated end appears in all cases to have been strengthened from within by fresh linings of shelly material, and the animal continued to secrete its shell till the *Ascoceras* portion was formed. When this was finished, at least exteriorly, the older portions of the shell were, as a rule, decollated, and hence the *Ascoceras* usually occurs by itself without the early, or *Nautilus* stage, and specimens like that figured are extremely rare, and in fact, only a few examples from Gotland have as yet been discovered.



Ascoceras sp., U. Ludlow, Isle of Gotland.

This strange and abnormal Cephalopod thus went through two sharply-defined stages during its growth, the *first*, probably of longest duration, the *Nautilus*, and the *second*, the *Ascoceras* stage. Broken-off stumps of the former stage have been found, which can be matched to five of the nine Gotland species of *Ascoceras*. They all show the characteristic peculiarities of a narrow thin shell, very gradually increasing in width, oval or elliptical in transverse section, and ornamented by oblique, transverse striæ. The body-chamber

is extraordinarily long, the intervals between the septa, at first short and irregular, become during the progress of the growth, unusually long. The siphuncle is narrow and straight, generally situated near the ventral surface. The decollation is oblique, following the direction of the septa.

The commencement of the *Ascoceras* stage is partially indicated by the increased distance between the septa. Very important changes in the shape of the animal, and probably also altered functions must have supervened, when its shell, thus rapidly, as it were, developed the very abnormal *Ascoceras* form. The septa were pushed up along the dorsal, and greatly depressed along the ventral side, where also the cochleate or bullate siphuncle is placed. In no other genus of the Cephalopoda are such aberrant septa developed. The most curious feature is that, with the exception of the lowest or oldest one, they are all incomplete, having a large lacuna in their central part on the dorsal side. They have thus been secreted only along the interior wall of the shell, leaving an empty space between their thin linings. Hence the different aspect they present in many of the figures in various publications. Thus they are continuous along the outside of a cast of the interior (Barrande, Céphalopodes, pl. 93, fig. 1), and truncated, discontinuous and resting on each other in a median, longitudinal section (Barr. *l.c.* pl. 93, fig. 4).

The discovery of these Gotland specimens of *Ascoceras* fully confirms the views of Bronn, expressed in 1855, at a time when neither he nor any one else had seen perfect specimens, as to the relationships of this genus. Barrande stated that *Ascoceras* possessed only a single deciduous chamber below the "lateral chambers," and he regarded the genus as the prototype of *Nautilus*. Bronn, on the other hand, invited by Barrande to give an opinion on the subject, suggested that if *Ascoceras*, at an early stage, threw off a portion of its growth, consisting of regular air-chambers with a siphuncle, then "*Orthoceras is rather to be designated as the early stage of Ascoceras*" (Neues Jahrbuch für Mineralogie, etc., 1855, p. 283, footnote **).

III.—Ostracoda from the Weald Clay of the Isle of Wight.

By Prof. T. Rupert Jones,[1] F.R.S., etc.

Contents.

1. *Cypris cornigera*, sp. nov. Woodcuts, Figs. 1*a*–1*f*, p. 536.
2. *Candona Mantelli*, sp. nov. Woodcuts, Figs. 2*a*, *b*, p. 536.
3. *Cypridea Valdensis* (Fitton).
4. *Cypridea Dunkeri*, Jones.
5. *Cypridea spinigera* (Sow.).
6. *Cypridea Austeni*, Jones.
7. *Darwinula leguminella* (Forbes).
8. *Cyprione Bristovii*, Jones.
9. *Metacypris Fittoni* (Mantell).

Some new species having been found in the Isle of Wight during the lately renewed examination of its geology by the Geological Survey, and the known Wealden species of that island not having

[1] Mr. C. D. Sherborn, F.G.S., has kindly assisted the writer in the examination of these Ostracoda.

been hitherto so distinctly indicated as might be, it is thought advisable to give some notes on, and a résumé of, this interesting series of fossil species.

1. CYPRIS CORNIGERA, sp. nov. Figs. 1*a*–1*f*, p. 536.

Valves suboblong; straight on the dorsal; elliptically rounded on the ventral margin; unequally rounded at the ends. Bearing a delicate sharp spine, or straight horn, at the front end of the dorsal line, pointing obliquely upwards (outwards and forwards). The extremities of the valves differ much in individuals, according to the state of preservation, and possibly according to sex. The front end is highest (broadest), and often boldly rounded, but sometimes showing a slight outward and downward slope at its upper part, just in front of the horn. The horn is, or has been, present on examples of both right and left valves, but it has very often been lost, and we have not been able to see it in place in a closed carapace.

The highest end, that which bears the spine, is also the most compressed (Fig. 1*f*); and therefore in all probability is the anterior; and hence the larger valve, overlapping the other ventrally, is the left (Fig. 1*e*).

The anterior and posterior margins of the valves are slightly bevelled on the inside. The hinge-line is simple. The surface is smooth; but, readily dissolving away, both inside and out, into numerous little pits with rounded mouths, according to some structural peculiarity, the valves appear to be coarsely and irregularly punctate in many instances.

This species occurs in two specimens of dark-grey shale, marked No. 3685 and No. 3688 (Geological Survey), from Atherfield Point, Isle of Wight. In the latter piece of shale it was associated with *Metacypris Fittoni* and a Fish-bone.

2. CANDONA MANTELLI, sp. nov. Figs. 2*a*, 2*b*, p. 536.

In a light-grey compact shale (No. 3791, Geological Survey), from the Wealden beds between Atherfield Point and Shepherd's Chine, there are on the bed-planes many Ostracoda belonging to *Metacypris Fittoni* (Mantell), small; *Cypridea spinigera* (Sow.), young individuals; *Cypridea tuberculata* (Sow.); *Cypridea Valdensis* (Fitton); and *Candona Mantelli*, sp. nov.

The last somewhat resembles *Candona candida* [1] (Müller), and is evidently allied both to that species and to *C. Phillipsiana*, Jones (GEOL. MAG. 1878, p. 108, Pl. III. Fig. 3), but the latter is too large, and much too high and less symmetrical. In the form before us the posterior extremity is more evenly rounded than in *C. candida*, and the anterior is not so high. Of the new species the right valve figured in outline (Fig. 2*a*) is the largest and best preserved of the many specimens on the shale.

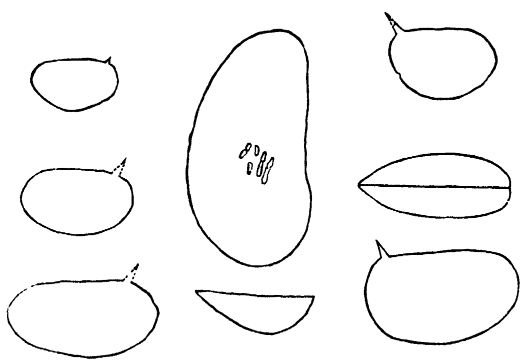
Subreniform, broader (that is, higher), and more boldly curved behind than in front; elliptically arched on the back, slightly sinuous on the ventral margin. Surface smooth and very delicately

[1] See GEOL. MAG. 1878, p. 108, *footnote*.

punctate; almost equally convex, but sloping more rapidly in the dorsal region; hence the edge-view of the carapace would be lanceolate, and the end-view (Fig. 2*b*) acute-ovate. The ventral margin has a minutely-frilled appearance, which is lost, however, where the edge curves inwards at the middle.

The spots marking the muscular attachment on each valve consist of four oblique, parallel, but rather irregular, rows of little oval marks. These are in pairs, which unite at their ends in three, but remain separate in one, of the groups. On the inside of the valve the spots are little depressions; on the outside they appear translucent. The pattern is more like that of *Cypris* (*Candona*) *reptans* (fig. 7*e*, pl. 1, Monogr. Tert. Entom.), than that of *Candona candida*; the direction, however, of the rows of little marks is from the postero-dorsal to the antero-ventral region, which is contrary to the usual condition for muscle-spots in such a form of valve.

As this *Candona* differs from those already known, I propose to name it after my old friend the late Dr. G. A. Mantell, one of the most zealous elucidators of the geology of the Isle of Wight, and of its Wealden strata in particular.



Cypris cornigera, Jones.
FIG. 1*a*. A right valve of a young individval.
,, 1*b*. A right valve of medium growth.
,, 1*c*. A long and low (narrow) variety; right valve.
,, 1*d*. A short and high (broad) variety; left valve.
,, 1*e*. The largest specimen; outline of left valve.
,, 1*f*. The largest specimen; outline of edge-view of carapace.

Candona Mantelli, Jones.
FIG. 2*a*. Outline of a right valve. (Anterior end placed upwards.)
,, 2*b*. Outline of the end view of the valve.

Magnified 20 diam.; drawn by Mr. C. D. Sherborn, F.G.S.

3. CYPRIDEA[1] VALDENSIS (Fitton).

This was the *Cypris faba* of Sowerby, "Mineral Conchology,"

[1] This genus is described at large in the Quart. Journ. Geol. Soc. vol. xli. 1885, p. 336. Remarks on the possible alliance existing between *Cypridea* and *Chlamydotheca* have been made by Dr. G. S. Brady in the "Proceed. Zool. Soc." 1886, p. 90; and in the "Journ. Linn. Soc." vol. xix. 1886, p. 200, 201.

1824, pl. 485, pp. 136–8; and was named *Cypris Valdensis* by Dr. Fitton[1] in 1836. See Geol. Mag. 1878, p. 109 and 277, Pl. 3, Fig. 11; and Quart. Journ. Geol. Soc. vol. xli. 1885, pp. 315–318, and 336–337. It is of very general occurrence in the Wealden beds,[2] especially the Weald Clay, and notably in the dark and thinly-laminated shales at Compton Bay in the Isle of Wight. It occurs, but is rare, in the Purbeck beds of Dorset.

4. Cypridea Dunkeri, Jones.

Cypridea Dunkeri, Jones, Quart. Journ. Geol. Soc. vol. xli. 1885, p. 339, pl. 8, figs. 9, 10, 17.

To the synonyms mentioned at p. 339, *op. cit.*, add:

Cypridea granulosa (Dunker), Jones, Geol. Mag. 1878, p. 110, Pl. III. Fig. 16.

This species is rather rare, but occurs in the Weald Clay of Grange Chine,—West of Brook Point,—Brixton Bay,—Atherfield,—and Sandown, in the Isle of Wight. It is rarer elsewhere, but has been found in the Wadhurst Clay and the Netherfield Limestone of Sussex, and in the Upper and Middle Purbeck beds of Dorset.

5. Cypridea spinigera (Sowerby).

Cypris spinigera, Sowerby, in Fitton's Memoir "On the Strata below the Chalk," Trans. Geol. Soc. ser. 2, vol. iv. 1836, p. 345, pl. 21, fig. 3. Figured also by Mantell, Lyell, and other authors.

Cypridea spinigera, Jones, in Morris's Catal. Brit. Foss. 1854, p. 104.

Cytherideis unicornis, Jones, Mem. Geol. Surv. Isle of Wight, 1856, p. 158, pl. 7, figs. 24–26; Monogr. Tert. Entom. 1856, p. 48.

Cypridea Valdensis, Bristow, Mem. Geol. Surv. Isle of Wight, 1862, p. 4, fig. 1.

Cytherideis unicornis, Jones, Geol. Mag. 1870, pp. 157, 158.

Cypridea spinigera, Jones, Geol. Mag. 1878, p. 109.

——— Jones, Q.J.G.S. vol. xli. 1885, pp. 316, 333, and 334.

——— Jones and Sherborn, Geol. Mag. 1887, p. 386.

In the Quart. Journ. Geol. Soc. 1885, *Cypridea spinigera* was mentioned as being common in the upper part of the Weald Clay at Compton Bay, Atherfield, and Sandown in the Isle of Wight, and as occurring also in the Wealden beds, but more rarely, of Sussex and Surrey. We now find that it occurs abundantly in the Tertiary beds of Hamstead Cliff on the north coast of the Isle of Wight. Specimens from this locality were described and figured in the Geol. Surv. Memoir I. of W. 1856, under the name of *Cytherideis unicornis*, as a subreniform Ostracod, sulcate and tuberculate when young, but with a sharp spine on each valve when adult. Careful examination of a further series of specimens leaves no doubt that it is the same species as that so plentiful in some of the Wealden strata. The Tertiary specimens are not so well preserved as those in the Wealden clays, nor are they so abundant; but many perfect specimens, young and adult, can be readily matched from the two formations. The Tertiary specimens are plentiful in a crushed state on the laminæ of a dark-grey marl ("D 6," Geol. Survey) of the Lower Hamstead series, Hamstead Cliff.

Note.—This species, or one extremely like it, has turned up in a specimen given to me by the late Dr. Mantell as coming from the

[1] Another species (*Cypridea Austeni*) was figured in his memoir instead of the true *Cypridea Valdensis*. See Geol. Mag. 1878, p. 277.

[2] See Q.J.G.S. 1885, pp. 333 and 334.

Oxford Clay of the Trowbridge Railway-cutting, Wiltshire, and also in a piece of the Oxford Clay of Skye, collected by Messrs. Geikie and Young, and there associated with *Estheria.* If its freshwater habitat in the Hamstead series be a criterion, and if these other specimens prove trustworthy, it points to more freshwater or estuarine conditions in the Oxfordian Series than are usually thought of.

6. CYPRIDEA AUSTENI, Jones.

Cypris Valdensis, Fitton (*in part*), Trans. Geol. Soc. ser. 2, vol. iv. 1836, p. 204, etc., pl. 21, fig. 1. Copied by various authors.
—————— Mantell, Wonders of Geology, 7th edit. 1857, vol. i. p. 419, lignogr. 104, fig. 3.
—————— Lyell, Elements of Geology, 6th edit. 1865, p. 346, fig. 341.
—————— Mantell, Geol. Excurs. Isle of Wight, 3rd edit. 1874, p. 223, lignogr. 25, fig. 3.
Cypridea Austeni, Jones, GEOL. MAG. Dec. II. Vol. V. 1878, pp. 109, 110, 277, Pl. III. Fig. 8.

This oblong *Cypridea* was figured by Fitton instead of the real ovate *C. Valdensis*, and it has been often copied for the latter. The figures in Mantell's works quoted above are given by him as representing specimens from the Wealden beds at Brook Bay, Isle of Wight. As such they may be noticed here, although possibly *C. Valdensis* may have been really intended, and the figure copied from Fitton by mistake.

In the same lignograph Mantell gave a figure of *Cypridea spinigera* (after Sowerby's drawing), as having also been got from Brook Bay. He also copied his fig. 2 from Sowerby's fig. 4 in Fitton's Memoir, namely, *Cypridea granulosa* (Sow.), the same as *Cypridea fasciculata* (Forbes), as an Isle-of-Wight specimen; but that was certainly an error, for that species occurs only in the Middle Purbeck beds. See Q J.G.S. vol. xli. pp. 340–342.

Cypridea Austeni has been found at Peaseworth, in Surrey, and at Shotover, near Oxford.

7. DARWINULA LEGUMINELLA (Forbes).

Quart. Journ. Geol. Soc. vol. xli. 1885, pp. 332, 333, 346, pl. 8, figs. 30 and 31.

This little Ostracod occurs in the Weald Clay at Atherfield and Sandown; also in some Wealden beds of Sussex and Kent, in the Upper and Middle Purbecks of Dorset, and the so-called Wealden (Purbeck ?) beds of North Germany. In the GEOL. MAG. April, 1886, p. 147, Pl. IV. Figs. 4 *a*, *b*, *c*, this species is recorded also from a Jurassic freshwater bed in Colorado.

The genus is the type of a separate family according to Brady and Robertson, "Monogr. Post-Tert. Entom." 1874, pp. 116 and 140. As the name was changed from *Darwinella* to *Darwinula*, the family name is now *Darwinulidæ*. *D. Stevensoni*, B. and R., is abundant in the fen rivers of the East of England.

8. CYPRIONE BRISTOVII, JONES.

Quart. Journ. Geol. Soc. vol. xli. 1885, p. 344, pl. viii. figs. 27, 28, 29, 32.

An additional occurrence of Wealden Ostracoda discovered by the Geological Surveyors in the Isle of Wight is a hardish buff-coloured marl, marked "3908," from the "Wealden Cliff opposite Compton

Chine," crowded with *Cypridea Valdensis*, *Cypridea Dunkeri*, *Metacypris Fittoni*, and *Cyprione Bristovii*.

The last-mentioned species has been found also in the Tunbridge-Wells Sand at Lindfield and Tunbridge (?), in the Wadhurst Clay near Hastings and Bexhill, in the Upper and Middle Purbeck beds of Dorsetshire, and in the equivalent beds of North Germany.

Cyprione probably belongs to the *Darwinulidæ*.

9. Metacypris Fittoni (Mantell).

Cypris tuberculata, Sow. *(in part)*, Trans. Geol. Soc. ser. 2, vol. iv. 1836, pp. 177, &c., pl. 21, fig. 2 *a*.

Cypris Fittoni, Mantell, Medals of Creation, 1844, vol. vii. p. 545, lignograph 119, fig. 2.

Cypridea ? Fittoni, Jones, Geol. Mag. 1878, p. 277.

Cythere Fittoni, Jones. Quart. Journ. Geol. Soc. 1885, vol. xli. p. 333.

Metacypris Fittoni, Jones, in Prestwich's 'Geology,' vol. ii. 1888, p. 263, fig. 137*a*.

This species is common in some beds of the Weald Clay of the Isle of Wight, especially at Compton Bay,—on the west of Brook Point,—at Brixton Bay,—at Atherfield, and Sandown Bay. It occurs also at Punfield Cove near Swanage, and at Pulborough and Pallingham, Sussex, in the Weald Clay; in the Tunbridge-Wells Sands at Lindfield; and in the Wadhurst Clay near Hastings. It is not rare also at some places in the Weald Clay of Kent (near Maidstone, Great Chart, Aldington, and Hythe), and the Tunbridge-Wells Sands at Langton Green. Also (doubtfully) in the Weald Clay near Hazlemere in Surrey.

The genus *Metacypris* was first noticed by G. S. Brady in 'Nature,' 1870, p. 484; and was found living, but not abundantly, in the tidal waters and "Broads" of the East of England by G. S. Brady and D. Robertson. There was only one species (*M. cordata*) met with, and they determined it as more probably belonging to the Cytheridæ than to the Cyprididæ. See Ann. Mag. Nat. Hist. ser. 4, vol. vii. pp. 19, 20; vol. ix. p. 51; and Monogr. Post-Tert. Entom. 1874, pp. 112 and 116. Also Quart. Journ. Geol. Soc. vol. xli. p. 344.

Besides the *M. Fittoni* mentioned above, there are several other fossil species. *M. Forbesii* is one of the leading fossils of the Middle Purbeck beds of Dorset (Ridgway, Durlston Bay, and Mewps Bay), *op. cit.* p. 346. In the Geol. Mag. April, 1886, p. 146, Pl. IV. Figs. 1 *a*, *b*, *c*, this species is also described from a Jurassic freshwater or estuarine limestone of Colorado, where it is associated with two other species, namely, *M. Bradyi* and *M. Whitei*,[1] *loc. cit.* Pl. IV. Figs. 2 *a*, *b*, *c*, and 3 *a*, *b*, *c*. *M. conculcata*, Jones, from a similar estuarine formation at Bahia in Brazil,[2] as well as *M. strangulata*, Jones, from Tertiary beds in the Province of Nagpur, Central India,[3] are referred to in the same paper, pp. 146, 147.

One of the chief characteristics of *Metacypris* is the submedian transverse suture on the dorsal region. This is very strong in *M. Fittoni*, and is the feature which led Mantell to separate this species from its somewhat similar companion, *Cytheridea tuberculata*.

[1] These three species have been described briefly and figured in the 'Bulletin U.S. Geol. Surv.' No. 29, May, 1886, pp. 23, 24, pl. iv. figs. 22-26.

[2] Quart. Journ. Geol. Soc. vol. xvi. 1860, p. 266, pl. xvi. figs. 3 *a*, *b*.

[3] *Ibid*, p. 187, pl. x. figs. 73 *a*, *b*, *c*, *d*.

IV.—The Sculpture of Alpine Passes and Peaks.[1]

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

THERE are two facts which are closely connected with the present condition of the Alps—(1) that the rainfall on the Alpine slopes on the Italian side of the watershed, as a rule, is heavier than that on the other side, and (2) that the valleys also are steeper. It is indeed true that the distance from the watershed of the Central Pennines to the lakes on either side, north or south, is not very different, but the level of those on the latter is some 700 feet below that of those on the northern. This difference of level is especially marked in the upper part of the valleys, places correspondingly situated being always lower on the southern than on the northern face; for instance, Zermatt is rather above Macugnaga, but as the crow flies it is more than double the distance from the watershed.

For both the above reasons denudation will proceed more rapidly on the slopes of the Alps facing southwards or eastwards, that is, towards Italy, and thus the valleys in them will be cut back more quickly and be more precipitous at their heads than in the northern or western slopes. From this results a singular configuration of the uppermost parts of a valley, which is commonly exhibited by the passes selected for the construction of high roads. The usual form of a pass in the higher Alps, as every climber knows, is this: you follow a valley which at last leads you by a final ascent, more or less steep, to a gap or saddle between two peaks, on the other side of which a similarly formed valley is found to descend. Of such passes every variety exists, from the depression which must be reached by climbing a rocky wall, like the east side of the Strahleck or the south side of the Sella Pass, to those like the Col de la Valpelline, where the final acclivity is comparatively slight. Occasionally, however, we meet with a type of pass of which the Maloya, at the head of the river Inn, may serve as an example. Noted as one of the lowest gaps across the watershed of the Alps, for its summit is barely 6000 feet above sea-level, its structure offers a problem which at first sight is sufficiently perplexing. The valley of the Inn ascends, on the whole gradually, to Samaden, where the river is joined by a torrent which carries the drainage from the northern face of the Bernina group. But though this brings the greater volume of water, it occupies a glen which is, orographically, of secondary importance, and the main valley continues onwards in a south-westerly direction towards the Maloya Pass. Samaden is about 5600 feet above the sea; from it a rather steep but short ascent brings us to the level of the St. Moritzersee, the elevation of which is about 5800 feet. We have now entered a rather broad and almost level valley, enclosed between mountains which rise on either side from 4000 to 6000 feet above it, the floor of which is occupied to a considerable extent by a group of shallow lakes. This trough is more than nine miles long; yet the Silsersee at its upper end is only 66 feet higher than

[1] An extract from one of the "Tyndall Lectures" delivered at the Royal Institution in 1888, by Prof. T. G. Bonney, D.Sc., F.R.S.

the St. Moritzersee; hence the fall is only 15 in 10,000, or, roughly speaking, about seven feet in a mile. The Maloya Kulm is a very short distance from the head of the Silsersee, and is only a few feet higher than it; the height assigned to the lake being 5872 feet, and to the pass 5942 feet. I doubt, indeed, whether the latter measurement indicates the lowest point, and think that it would be possible to divert the waters of the Silsersee from the Black Sea to the Adriatic by a comparatively shallow cutting. But no sooner have we traversed this low ice-worn floor of rock than the scene changes in a moment; we are standing on the brow of a series of lofty cliffs; the road swings away to the left to seek a less precipitous part of the enclosing head of the valley, to the floor of which—nearly a thousand feet below—it descends by a series of zigzags. To what are we to attribute this singular configuration: this flat, almost level trough driven right through the crest of the Alps, and terminating so abruptly at the brink of a range of precipices? There is the river valley—one which seems to suggest, nay, to demand, the action of strong torrents for its making—and no torrent is to be found, for the mountains from which it could flow have vanished, and instead of a ridge we have vacant air!

Is this trough the work of glaciers? Certainly it bears everywhere the marks of moving ice. Members of the School of Ramsay might cite its wide but shallow lake basins as examples of the excavatory power of ice, and here, though I could point out some difficulties in the application of their theory, I should not be surprised if their claim were substantiated. But the glacier which exercised any erosive action on this trough can only have been formed by the fusion of ice-streams which descended from the mountains on either side. Hence it may have modified the superficial features, but in no case can it be said to have excavated the trough, because, as already stated, there is not even a ridge at its head. Suppose the trough of the Maloya covered deep with snow and ice, it is obviously impossible that this can have exercised any erosive force of importance in the direction of the flow of the Inn, because here it would be almost at rest. Moreover, we can prove that when the glaciers of the Alps were vastly greater than now, and the Maloya was thus buried, the actual watershed of the pass—that is, the ice-worn rock on which the Kulm hotel now stands—was swept by a glacier which had its origin among the peaks on the southern side of the watershed—one represented at the present day by the Forno glacier; for on this rock are strewn erratics of the peculiar porphyritic granite which forms the crags on the western side of that glacier. We have only to stand on this ice-worn plateau among the erratics which mark the overflow of the southern ice-stream, to glance at one moment along the unbroken trough on the Swiss side, and the next down the steep crags into Italy on the other, in order to realize how slightly the glaciers of the Great Ice Age can have modified the pre-existent natural features of the district, and to justify us in assigning to them a very secondary place among the graving tools employed by Nature.

What explanation, then, must be given of this singular trough?

I regard it as anterior in its dominant features to the extension of the ice. I suppose that when it was made no glacier intruded on to its floor; perhaps there were no glaciers among the peaks; at any rate, I do not suppose that the region of snow and ice was more extensive than at present. I believe, for I can find no other explanation, that in this part of the valley of the Inn we have a true valley of erosion, comparable, let us say, with the upper part of the Val Rosegg, one of those steps which not unfrequently precede the final ascent to the watershed. But I suppose that the watershed in this case once lay some distance further south, perhaps not very far away from the present frontier-line between the Engadine and Italy, say passing somewhere above the site of Vico Soprano. From this ridge the Inn then flowed towards the northeast, while on the other side the Maira descended towards the southwest. At the present time the Maira falls about 2500 feet between Vico Soprano and Chiavenna, a distance of about 12 English miles, say full 200 feet a mile, and the Maloya Kulm is nearly 2400 feet above Vico Soprano, a distance of about 5 miles as the crow flies, giving a total fall of almost 5000 feet in some 18 miles of the river course, say 5 in 100 on the average; while the Inn, as has been said, descends at first almost imperceptibly, and between St. Moritz and the Finstermünz only falls 94 in 10,000, which is rather less than 1 in 100.

Obviously, then, apart from any consideration of rainfall, the erosive force of the Maira would be far greater than that of the Inn. Thus the streams of the former would bite more deeply into the dividing range than those of the latter. The intervening mountain mass was quarried away far more rapidly on the southern side, until at last the corrie at the head of the Maira ate its way back through the dividing ridge, and actually cut away the slopes by which the streams descending towards the Engadine were formerly fed. Thus I regard the floor of the Upper Innthal as the decapitated remnant of a very ancient valley, which, while important changes have been occurring on either side, has remained comparatively unchanged, because denudation must needs cease when its motive forces are gone. When the weapons are snatched from the hand of the destroyer, when his arm is paralysed, then he must cease from troubling and the weary may rest.

If we examine a good map of the district, we find an interesting confirmation of the explanation just offered. The tributary glens of a river system bear a general resemblance, as every one knows, to the branches of a tree—they tend to converge in the direction of the flow, as twigs unite to branches, and branches to the trunk. It is true that the changes from valleys of strike to valleys of dip give rise to sharp turns and "kinks," not unlike those in the boughs of an aged oak; but we rarely find a valley running almost in the opposite direction to that of the stream to which it is a tributary. Yet the long glens occupied by the Albigna and the Forno glaciers run due north, while the Maira for some distance is flowing almost exactly in the line of the former glen, but in the opposite direction.

Moreover, the mouth of the upland glen leading to the Forno glacier is as nearly as possible on the level of the Maloya Kulm: its floor is reached from the latter by a track which keeps nearly at the same level, though the torrent which plunges downwards to the Maira has gashed the rock over which it rushes. Hence I believe that the streams from the Forno and the Albigna glens formerly flowed into the Innthal, as those from the Fédoz and Fex still do, but that, as the corrie at the head of the Maira gradually receded in a north-easterly direction, it intercepted and diverted, as its floor was on a lower level than theirs, first the torrent from the Albigna glen, and then that from the Forno. The diversion of these streams would, of course, augment the erosive force of the Maira, and correspondingly diminish the amount of denudation in the upper part of the Innthal. Indeed, I think it probable that the torrent from the Forno glen has indirectly aided in producing the precipices which separate the Maloya Kulm from the floor of the Val Bregaglia.

Instances like the above are far from rare in the Alps. Most of the passes traversed by the great high roads, such as the Genèvre, the Cénis, the St. Gothard, the Lukmanier, to mention no others, furnish us with examples of a nearly level plain of considerable extent at their summits; they are, in short, troughs driven through the range, not sharp-edged saddles on the range. To all these—very difficult to understand on the hypothesis that the watershed has always occupied its present position—the above explanation may be applied. I will only mention one other case, because it is in a region of sedimentary rock, seems no less anomalous than that which I have been describing, and brings us to a district where another difficulty demands an explanation.

On the Toblacher plateau—the water-parting between the Rienz and the Drave—the Ampezzo road turns off to cross the southern range in its course towards Venice. It passes through a deep trench in the dolomite mountains. On the one hand rise the grand spires of the Drei Zinnen and the turretted wall of the Cristallo; on the other the vast altar-stone of the Croda Rossa, with many subordinate summits. From Toblach to Landro, from Landro to near Peutelstein, the road is almost level. The rise from the entrance to the Höllensteinerthal to the shallow Durrensee, in which the crags of the Cristallo are mirrored, is less than 600 feet, though the distance is full six miles; and for the remaining six miles the total ascent is hardly more than 250 feet. The trough is then suddenly interrupted, almost as at the Maloya Kulm. From the northern, or rather the north-western side of Monte Tofana, a glen comes sweeping round, the floor of which is some hundreds of feet below the level of the pass; to this a steep and narrow track was the only means of descent until the present road, with its series of zigzags, was constructed. When the floor of this glen is reached, a more gradual descent leads to Cortina, which is a little less than 4000 feet above the sea. Here, then, we have a repetition, though on a smaller scale, of the physical features of the Maloya; and here, also, I can find no other explanation of the apparent anomaly than that the watershed once lay rather further to the south, and that as the main feeder of the Piave

deepened the valley between the Tofana and the Cristallo *massif*, it gradually cut away the rocky wall which once closed the glen to the west of Schluderbach.

But the head of the Pusterthal itself presents us with a somewhat similar anomaly, and this, singularly enough, finds a parallel at the head of the Etsch. The watershed in the former, though between the Adriatic and the Danube, is curiously ill defined. It is a flattish drift-covered plain, barely 4000 feet above the sea, perhaps a third of a mile wide, guarded on the one side by the slopes and crags of the crystalline schists of the central range of the Tyrol, on the other by the magnificent dolomitic cliffs of the southern range. On the west—from Welsberg to Niederndorf (4 miles) there is a rise of about 260 feet; from the latter place to Toblach (3 miles) a further rise of 150 feet; and from Toblach to Innichen, on the east side (2 miles), a descent of less than 100 feet. Thus the floor of the trough for some five miles does not rise and fall more than about 100 feet, and the average slope is less than 1 in 100. In the next eight miles the fall is only about 225 feet, which is still more gentle. But then it becomes more rapid; the valley contracts, its floor descends more sharply as the river passes through the Lienzer Klause, a defile cut into the crystalline schists and about nine miles long. Lienz itself, 28 miles from Toblach, is about 1750 feet below that place, while Untervintl, which is about the same distance on the western side, is some 300 feet higher than it. Here, then, I conclude that the original watershed must be placed to the east of the Toblacherfeld, and that the Drave has cut its way back into the upper part of the glen of the Rienz.

The pass of the Reschen Scheideck, which leads from the upper part of the valley of the Etsch to the Finstermünz in the valley of the Inn, exhibits a structure in some respects similar to that which has just been described. The Malser Heide, on which the pass lies, is a long and comparatively level trough, the watershed of which is less than 5000 feet above the sea (4898 feet). Thence the road declines gradually to Nauders (4468 feet), and then drops rapidly down to the gorge of the Inn, the level of that river being about 3700 feet above the sea.

To explain the structure of the region, I must go back to the time when the Inn had excavated a valley which was both shallower and narrower than that which it now occupies. Suppose that its bed was then about 5000 feet above the sea, on the level of the Reschen Scheideck; at that time the head waters of the Etsch may have descended from a ridge, the watershed of which lay near to the channel of the Inn. Gradually, as the latter river deepened and enlarged its valley, the ridge would be eaten away, until at last the head of the Reschen Scheideck trough was exposed. Then the brow of the declivity towards the Inn (as the rocks here are not very durable) would be rounded off, so that the edge of the old trough would not remain sharp, as in the case of the Maloya, but would be gently bevelled in the upper part, and thus the actual watershed would travel slowly and almost imperceptibly eastwards.

Instances where apparent anomalies may be explained by the

principle of the unequal rate of recession of the heads of valleys on opposite sides of a line of water-parting might readily be multiplied, but I will notice only one other, and that briefly. Many of you will remember the structure of the Pennine Alps at the head of the Gorner glacier. Between the pyramidal summit of the Matterhorn and the *massif* of the Breithorn there is the marked depression crossed by the Théodule Pass—a breach in the rocky wall which is some two or three thousand feet deep; for the summits on either side are respectively 14,705 feet and 13,685 feet above the sea, while the crest of the chain at the Théodule Pass is barely 11,000 feet. From the Breithorn the rocky rampart continues practically unbroken, in a general easterly direction, as far as Monte Rosa, its peaks being well over 13,000 feet in height, and even the gaps between them only about 1000 feet less elevated. In fact, from the Breithorn to Monte Rosa the crest of the range is never less than 12,700 feet above the sea. It culminates in the vast ridge of Monte Rosa, the highest peak of which is 15,217 feet above the sea, after which the watershed between Switzerland and Italy runs north, and we find another gap similar to that above mentioned, except that here a comparatively level snow-field is terminated by abrupt precipices on the eastern side. Every one who has crossed by one of the Weissthor passes, or who has ascended the well-known snowy hump of the Cima de Jazzi, will remember the startling contrast between the long and gentle ascent over slopes of snow on the western flank, and the precipitous descent on the Italian side. Between Monte Rosa and the Strahlhorn (13,750 feet) there is a gap of about three miles wide, the flattened crest of which undulates a little on either side of 12,000 feet. Besides this, a line of peaks, only a little subordinate to that of which Monte Rosa forms a part, terminates abruptly with the Strahlhorn almost on the watershed, instead of being prolonged, as might have been anticipated, by a spur on the southern side. Of this apparent anomaly we have not far to go in order to find an explanation. The head of the Val Macugnaga, which is a huge corrie, has cut back into the *massif* of Monte Rosa, and is partly enclosed by its eastern spur, which runs towards the Pizzo Bianco. The drainage from this corrie, starting in a northerly direction, sweeps round towards the east, passing under the great wall of cliffs which, as already mentioned, descends from the edge of the snow-field feeding the Gorner and the Findelen glaciers, and from that at the head of the Schwarzenberg glacier east of the Strahlhorn. Hence I conceive that the Strahlhorn was once part of a great spur thrown off from a range which extended in a direction rather east of north from Monte Rosa, and was elevated perhaps a couple of thousand feet above the present edge of the Gorner snow-field. The Cima de Jazzi might be a remnant of another spur from this range, and it is a noteworthy fact that the Monte delle Loccie, a peak over 12,000 feet on the eastern spur of Monte Rosa, is almost exactly on the line of the Strahlhorn axis.[1]

[1] Possibly the curious shelf or trough of the Saas Weissthor is really the half of an old pass between the Strahlhorn and a missing peak.

This range has been cut away, as the great glen of Macugnaga was being deepened and enlarged, devouring the mountain group by which it is fed.

I pass on to another peculiarity, which admits of a similar explanation. Not unfrequently the higher peaks, especially in the district south of the Little St. Bernard, project slightly from the watershed on to the Italian side, like bastions from a wall. Such is the case with the Ciamarella, the Roche Melon, the Viso, and others. The Viso, indeed, is wholly an Italian mountain, for it is the culminating point of a long and deeply gashed spur, extending towards the south-east from the main range of the Alps. Thé course, indeed, of the line of watershed is suggestive, for it forms about the head of the river Guil (flowing westward) a kind of cusp, near the point of which is the Viso. On the northern side of this cusp rise the tributaries of the upper waters of the Po; on the other, the feeders of a hardly less important Italian stream, the Vraita. To understand the orographical structure, I look back to a stage in the process of mountain sculpture when the line of watershed passed over the summit of the Viso, and its crest, elevated to perhaps a couple of thousand feet above the present level, ran in the same general directions as it now does, but some distance on the Italian side. The Guil continued to cut its way back towards the main peak, though slowly, as the slope of the upper part of the valley is not rapid. The glens of the Vraita on the one side of the peak and of the Po on the other side worked their way back more rapidly, and devoured the actual crest of the range. The descent on the Italian side is much more rapid than on the French; from the gaps, by which the range can be crossed from the latter country, to Crissolo in the Val di Po, is a drop of nearly 5000 feet. The descent from the Col de Vallante to Château Dauphin in the Val Vraita is about as much, while on the French side it would require some miles more walking to reach this level. Thus the Viso has been left projecting as a bastion. But nearly simultaneously with the above recession, two ravines, one tributary to the Po, the other to the Vraita, were cutting back into the curtain wall which connected the bastion peak of the Viso wall with the retreating crest of the watershed, until at last the heads of these glens met, and formed a kind of high-level ditch which isolates the peak from the actual watershed.

A similar principle may be applied to explain a very common feature in the higher regions of the Alps—namely, that the culminating peaks of important spurs are often hardly less elevated than those on the watershed. As an example, let us return to the Pennine range in the neighbourhood of Zermatt. The two branches of the Visp are divided and are bounded respectively by lofty ridges. A line drawn along the crest of the westernmost ridge would pass across the gap occupied by the Zmutt glacier to the peak of the Matterhorn; that drawn along the central ridge, as already said, would pass above the vast cirque at the head of the Val Anzâsca to the Monte delle Loccie, east of Monte Rosa, while that along the easternmost ridge ceases rather abruptly near the head of the Val

Antrona. On the first spur, full ten miles to the north of the Matterhorn as the crow flies, we find the Weisshorn, actually the higher by about 100 feet; the other peaks to the south being well above 13,000 feet, and the lowest gaps between them not much under 12,000 feet. Opposite to the Weisshorn rises the mass of the Mischabel-hörner, the highest peak of which almost reaches 15,000 feet, and there is no point in the range south of it till we have passed the Strahlhorn, which falls much below 12,000 feet, while its peaks are all over 13,000 feet above the sea. Lastly, in the rather less elevated range east of the Saaser Visp, we find peaks somewhat over 13,000 feet in height separated by passes which are not much below 12,000 feet. As may be inferred from what I have already stated, the principal gaps in the rocky rampart enclosing the head of the Gorner Visp correspond with the direction of its main axis, and of the tributary glens now occupied by the glaciers, Zmutt, Gorner, and Findelen. These gaps I attribute to the destruction of the original party walls by the recession of the heads of the Italian valleys. In order to comprehend the process by which the above-described structure has been produced we must dissolve away snow and glacier, and must replace the myriad millions of cubic yards of rock which have been removed by the action of water in all its forms. We will, however, for simplicity, suppose any covering of Secondary rocks already stripped off. We may then picture to ourselves a broad arch of crystalline rock, slowly rising, perhaps not without pauses, until its flattened crown is full three miles above the sea. Its chord extends from the present valley of the Rhone on the one side perhaps to the Italian plain on the other. Into this mass the streams which start from its higher surface cut deeply, working their way backwards, and excavating the valley, so that every peak is a "locus of least denudation," standing like one of those prisms of earth which excavators leave to indicate the amount which they have removed.

It may be asked why, if the above explanation be correct, do we not find spurs on the southern side of the Pennines comparable with those on the northern. I reply because they have suffered more from and have been partly destroyed by the more rapid recession of the valleys on this side. As their tributary glens enlarge, as the great corries at their heads are extended, laterally as well as backwards, so the intervening masses suffer from corrosion, and at last even the peaks, which have for long been spared, must obey the general law, "Dust thou art and unto dust thou shalt return."

But on this subject passing time forbids me to dwell longer. I will only say that I believe the principles which I have indicated to be of general application in all mountain regions. There are, however, two topics indirectly connected with questions of Alpine sculpture which call for a brief notice. These are (*a*) what effects have snow and ice as erosive agents compared with running water, and (*b*) to what extent have the Alps, in the past time, been occupied by snow-fields and glaciers? I have already said that I believe that, compared with torrents, glaciers are erosive agents of secondary

importance.[1] I may add that snow-beds appear to have, comparatively speaking, a protecting influence. Still, snow-fields and glaciers in the upper part of a range act as storehouses for the water, and so keep the torrents always full; the former also give rise to endless streams which have a plunging action, and form precipitous cliffs, as may be seen in cirques; the latter increase the erosive power of torrents by rendering their waters muddy. I believe, therefore, that, wherever there is unprotected ground, the process of excavation is aided and accelerated by the existence of snow-fields and glaciers in the upper parts of the ranges. Hence I should infer that the sculpture of the more elevated regions progressed most rapidly when that of snow and ice was least extended.

V.—On a Mode of Using the Quartz Wedge for Estimating the Strength of the Double-Refracton of Minerals in Thin Slices of Rock.

By Major-General C. A. McMahon, F.G.S.

In some cases it is of practical importance to petrologists to estimate the strength of the double-refraction exhibited by doubly-refracting minerals in thin slices of rock under the microscope.

Babinet's compensator, a description of which will be found in Rosenbusch's *Microskopische Physiographie der Mineralien und Gesteine*, affords a means of accurately calculating the refractive indices of the rays into which light is divided in its passage through doubly-refracting crystals. Michael-Lévy also devised another exact method based on observations made on the tints presented by slices of doubly-refracting minerals, an account of which appeared in the *Bulletin de la Société Mineralogique de France*, and which is discussed in a work recently published by Michael-Lévy and Lacroix.

As these exact methods of calculating the double-refraction of crystals require special apparatus and are somewhat complicated, it may be worth while to describe a rough and ready method based on the use of the quartz wedge, which I have employed for some years, and which has yielded me useful results.

In order to explain this mode of using the wedge, I will suppose, in the first place, that we have our microscope arranged on our table with crossed Nicols, and that we have inserted a quartz wedge, made in the usual way (which is too well known to need description), in a slot in the eye-piece at an angle of 45° to the plane of polarization. If we look through the microscope with the apparatus fixed in this position, and before any object has been placed on the stage, a series of chromatic bands will be observed in the quartz wedge, each band consisting of a spectrum of colours in an ascending order; the colours of the first order of Newton's scale being the nearest to the thin edge of the wedge. The width of these bands depends on the thickness of the quartz and on the slope of the wedge, being broader in a flat wedge than in one cut at a considerable angle.

The usual way of employing the wedge for the purpose of estimat-

[1] Discussed in a part of the lecture not included in this extract.

ing the strength of the double-refraction of minerals is to compare the tint of the mineral with the corresponding tint in one of the chromatic bands in the wedge. The eye of the observer may thus be trained to determine whether the tint of the mineral under observation belongs to the first, second, or higher order of Newton's scale. This method is based on the rule that the stronger the double-refraction of a mineral, the higher will be the order of the tint exhibited by it when sections of different minerals cut in slices of uniform thickness and at the same angle to an optic axis are examined in transmitted light under a microscope.

In working this method I employ a quartz wedge specially made for the purpose,[1] which is similar to the ordinary wedge in all respects but one; namely, my wedge only occupies half the depth of the slot, so that the observer is able to directly compare the tint

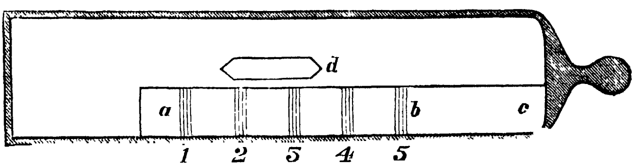


Fig. 1.—Diagram of quartz wedge used by the author.

of a mineral, say at *d* (Fig. 1), with the spectra seen in the wedge *a–b–c*, and so determine satisfactorily whether the observed tint belongs to the 1st, 2nd, or higher order of Newton's scale.

The method, however, which I desire to describe in the following pages differs from the above. It depends not on the order of the tint exhibited by the mineral under observation, but on the character of the phenomena produced in the quartz wedge by the passage of light through the mineral to the quartz.

Having fixed our microscope in the manner above described, viz. with a quartz wedge inserted in the *eye-piece* at an angle of 45° to the plane of polarization, let us examine a second quartz wedge placed on the stage of the microscope in a position at right angles to the axis of the wedge in the eye-piece. In this position the velocity of the extraordinary ray is retarded in one of the two plates of quartz and accelerated in the other; and, at the point where the velocity of the extraordinary ray, on emergence from the upper quartz wedge, becomes the same as that of the ordinary ray, there is no double-refraction and a dark line appears.

If we examine the thin edge of the quartz on the stage of the microscope with the wedge in the eye-piece, the black line will be seen near the thin edge of the analyzing wedge, with spectra of the 1st, 2nd, 3rd, and higher orders rising in succession beyond it towards the thick end of the wedge. If we allow the analyzing quartz wedge in the eye-piece to remain stationary, and move the wedge on the stage of the microscope so that thicker and thicker portions of the quartz are successively brought within the range of

[1] The wedge should be a tolerably flat one so as to give a wide spread of colour.

vision, we shall find that the black line, above alluded to, moves gradually along the analyzing wedge from its thin towards its thick end, and spectra (in inverse order) of the 1st, 2nd, 3rd, and higher orders of Newton's scale, come in between the black line and the thin end of the analyzing quartz wedge. These chromatic bands of colour, as they rise in the scale of Newton's orders, become fainter, and fainter, until at last the eye fails to detect them and the spectra merge into white light.

This experiment shows that, other things being equal, the distance of the black line from the thin end of the wedge is proportional to the thickness of the quartz on the stage of the microscope.

If we now substitute for the quartz on the stage of the microscope a wedge of calc spar cut in precisely the same way with reference to its optic axis as the quartz wedge is cut, and of the same thickness as the latter, and placed in such a position on the stage that the axis of greater elasticity of the calcite is parallel to the axis of less elasticity of the quartz, we shall find that the thick end of the analyzing quartz wedge is insufficient to make the dark line and the spectra visible when we examine even the thin edge of the calcite. Indeed, so much more powerful is the double-refraction of calcite than that of quartz, that even the thick ends of two ordinary quartz wedges, superposed one above the other in the eye-piece,[1] are insufficient for the purpose.

If for wedges we substitute flat slices of different minerals of uniform thickness cut at the same angle to the optic axis, but differing from each other in the intensity of their double-refraction, we shall find the distance of the dark line from the thin edge of the analyzing quartz wedge, and the *number* of chromatic bands that come in between it and the thin end of the wedge, depends upon the intensity of the double-refraction of the mineral under observation.

I find, in short, by noting the position of the dark line in the quartz wedge, and by observing the number of the chromatic bands that appear between it and the thin end of the wedge, that it is possible to estimate the comparative thickness of the slice, when we are dealing with slices of the same mineral; or the strength, or feebleness, of the double-refraction possessed by a mineral when we have several sections of the same mineral in a slice of rock prepared for the microscope.

The application of the above principle to the examination of thin slices of rocks is complicated by the fact that the sections of minerals contained in them vary not only in thickness (for few slices, microscopically considered, are exactly equal to each other in thickness), but also in the angle to an optic axis at which they are sliced.

This difficulty, however, must be faced, for it is one that is not peculiar to the method described in these pages, but is common to *all* methods of estimating the double-refraction of minerals scattered promiscuously in rock-sections.

[1] The eye-piece of my microscope is furnished with two slots, one above the other, so I can either use two wedges at once or combine one wedge with an eye-piece micrometer.

When a mineral contained in one slice has to be compared with a mineral in another slice, we must, if we desire to be exact, measure the thickness of our slices, and take the disturbing element of the difference of their thickness into consideration. But for the rough and ready mode of estimating double-refraction now under description I have not found this necessary. Rock-sections prepared by a skilful lapidary—especially if we compare slices of rocks of the same class [1]—do not differ greatly in thickness; and if we always employ the same lapidary, we shall not go far wrong if we assume that our slices are, for the purpose in hand, of fairly equal thickness.

The difficulty connected with the fact that slices of rocks for microscopic study are made promiscuously without reference to the orientation of individual minerals, and that the sections of the latter are consequenly cut at varying angles to their optic axes, may to a great extent be overcome by selecting for examination those crystals that display the brightest colours under crossed Nicols; for the sections that polarize brilliantly are presumably those made approximately parallel to an optic axis.

Notwithstanding the difficulties alluded to above, the quartz wedge is a delicate, as well as handy instrument, of great value in the practical determination of the minerals met with in rock-sections. It enables one, for instance, to separate at a glance such minerals as rutile, dolomite, calcite, sphene, anatase and zircon, from all others likely to be met with. It will enable us to detect even a speck of granular calcite of microscopic size imbedded in another mineral. The double-refraction of the above minerals is so powerful that when they are tested in the way above described, the dark line [2] does not come into view until the thick end of the wedge begins to pass over them, and the spectra, instead of being of normal width and distance apart, are narrow and crowded together. The character of these narrow and crowded spectra is so remarkable that an observer who has once seen them can never mistake them for those of a mineral possessing a less intense double-refraction.

So powerful is the double-refraction of rutile, calcite, and sphene, that I sometimes find it necessary to employ two quartz wedges, one above the other, in order to bring the spectra within the range of vision. Occasionally the mass of a crystal resists even the double wedge, and the spectra can only be seen in portions of the crystal, where, owing to its brittleness and liability to fray in the process of grinding, or from its edges overlapping other minerals, specially thin sections are exposed to view.

Minerals of feeble double-refraction, on the other hand, may be separated from those of strong, or of even average double-refraction, with equal confidence. If we examine such minerals as chlorite, nepheline, and apatite, we find that the dark line, described above, either appears *on the very edge* of the quartz wedge, or is just

[1] Basalts, for example, are usually sliced thinner than granites.

[2] When testing for double-refraction the stage must be revolved until the dark line appears in the mineral under examination. The azimuth in which this appears affords another valuable means of distinguishing between different species.

beyond the range of vision. In the latter case I call in the aid of the $\frac{1}{4}$ undulation plate: on inserting this above the object-glass, the spectra seen in the quartz wedge are shifted up the wedge towards its thick end, and the dark line previously beyond the range of vision is brought on to the edge of the wedge.

In the case of the above-mentioned minerals possessing very feeble double-refraction, the dark line appears, as just stated, at the *very edge* of the quartz wedge. In the case of sanidine, orthoclase, and other minerals of equally weak[1] double-refraction, the dark line appears *clear* of the edge of the wedge, but no chromatic band comes in between it and the edge. As we examine minerals of higher and higher double-refraction, we shall find the position of the dark line is more and more shifted towards the thick end of the wedge, and more and more chromatic bands come in between it and the thin end of the wedge.

Thus, to give a few examples drawn from my own experience of slices prepared by different lapidaries which are *not* all of equal thickness, I find that quartz in such sections rarely exhibits more than one and never more than two chromatic bands between the dark line and the edge of the wedge; whilst such minerals as muscovite, olivine, and actinolite, commonly present three, and not unfrequently as many as five such bands.

We have here, then, a means not only of comparing sections of minerals of equal thickness in the same slide, but sections of crystals in different slides, and we have a standard by which we may estimate the strength of their double-refraction. A mineral of strong double-refraction sliced at so high an angle to an optic axis as to approximate a plane normal to that axis will, of course, exhibit little or no double-refraction, and in the phenomena it presents will resemble a mineral of feeble double-refraction sliced approximately parallel to an optic axis; but a mineral of weak double-refraction can never exhibit the phenomena characteristic of one of strong double-refraction. When therefore. on testing a mineral with the quartz wedge, we find two, three, or five, chromatic bands appear between the dark line and the edge of the wedge, we know for certain that the mineral possesses stronger double-refraction than those minerals which never, in slices of normal thickness, present to our view more than *one* such chromatic band.

Even in the case of minerals of strong double-refraction sliced approximately normal to an optic axis, we gain something by examining them with the quartz wedge, for we learn from the position of the dark line[2] that the section is one either approximately normal to an optic axis, or is one of a mineral of feeble double refraction. If the former is the case, the mineral will exhibit characteristic appearances when examined in converging polarized light. If, on the contrary, it does not show any phenomena capable

[1] I use the word *weak* to indicate a slightly higher double-refraction than *feeble*. Thus, $\gamma - \alpha$ for chlorite is 0·001, but for sanidine is 0·008.

[2] The dark line will not appear in any azimuth in a section *quite* normal to an optic

of interpretation when examined in the usual way with converging polarized light, we know that we have before us not an axial section, but a mineral of weak double-refraction sliced in another direction.

In cases where a mineral is of such microscopic size as to be less in diameter than the width of one of the chromatic bands exhibited by it, we can still easily count the number of chromatic bands that come in between the dark line and the thin edge of the wedge, if we confine our observations to one colour (red I find the most convenient), and, as we move the wedge forward over the mineral, count the number of times it assumes that colour before extinction takes place on the micro-crystal entering the dark line or region of no double-refraction.

In the examination of pounded fragments of minerals with the aid of a quartz wedge we must carefully consider the element of thickness, and we must confine our observations to flat surfaces parallel to the plane of the glass slide.

As an illustration of the close approach to accuracy that may be obtained by the use of the quartz wedge in the way described above, I may mention the following example. As Rosenbusch does not give the value of $\gamma - \alpha$ for sphene in his *Microskopische Physiographie,* I recently wrote to inquire of a friend whether he could give me the required information, and I expressed at the same time my conviction that the double-refraction of sphene was, in intensity, somewhere between that of zircon and calcite. It turned out that the refractive indices of sphene have been worked out by M. Lévy and Lacroix, and are given in their book *Les Minéraux des Roches* just published. $(\gamma - \alpha)$ or $(n_g - n_p) = 0{\cdot}121$. So that sphene really occupies the position I had assigned to it on the evidence afforded by the rough and ready use of the quartz wedge; the values of $\gamma - \alpha$ for the three minerals being: calcite, 0·172 (Rosenbusch); sphene, 0·121 (M. Lévy); and zircon, 0·060 (Rosenbusch).

VI.—On a Remarkable Dyke in the Serpentine of the Lizard.

By Alex. Somervail.

THE dyke in question occurs at the extreme north end of Pentreath Beach, which is about a quarter of a mile to the south-east of Kynance Cove.

The dyke forms a portion of the "granulitic group" of Prof. Bonney, which is now known to be of igneous origin, and consists of banded gneissic rocks, some of which are like a granite, other portions like a diorite, the latter always more or less porphyritic.

This rather complex rock is here, as in many other localities, thrust through the serpentine, but, in this particular instance, it exhibits more remarkable features than any other dyke known to me in the Lizard area.

The dyke forms the central part of a small chine or gully. It rises from the shore to the top of the cliff, which is about 150 feet in height, and can easily be followed throughout its entire upward course, as the cliff here is not very precipitous. The decomposition

of the dyke along with that of the serpentine on either side of it being the cause of the gully.

From the main trunk of the dyke near its base a number of branches or veins are sent off which traverse the serpentine more in a lateral and diagonal direction than a vertical one, as does the parent mass.

These processes when taken together display a wonderful variety of rocks, most of which are to be found in the main dyke. These rocks in their extremes vary from a dull-looking trap, which many would term a dolerite, to a dark lustrous diorite, full of sparkling hornblende, then a greyish and also a reddish granite, followed by milk-white quartz, also masses of flesh-coloured felspar, with large plates of biotite, as well as some intermediate varieties of these rocks. At a height of about 60 feet from the beach, in the main dyke on the north side of the gully, the diorite, granite, etc., are well mingled together, and other alternations are found at other portions, as well as in the branches where the dull-looking trap occurs.

The inference to be drawn from these facts is, I think, that all the minerals and rocks mentioned have been differentiated out of the same magma during the cooling process, the ordinary selective law of chemical affinity separating the basic from the acidic types.

The lesson to be derived from this dyke also seems to me to have a very important bearing on the other rocks of the same area.

De la Beche, followed by Prof. Bonney, regards the schists, serpentine, gabbro and the granitic veins as belonging to widely separated intervals of geological time. When these are viewed in their massive relations to each other, there seems much to support this view, an opinion in which I also at one time partially shared; but repeated examinations have shown me that certain relations which held good in one district were very obscure, or flatly contradicted, in another. In fine, the whole of these rocks (schists included) really seem more or less to interlace each other, and to be the product of one great period of eruption, if not the product of the same magma, heterogeneous or complex it may have been, rendered still more so, by cooling under different conditions.

Among other proofs of this, there is what seems to me a very decided transition of the various Lizard rocks into each other, not promiscuously perhaps, but by way of the hornblende into the serpentine, also the hornblende into the gabbro. In the former case, as in the intermediate varieties of these rocks forming the islands and coast of Kynance Cove, and of many other localities. In the latter case, as in the curious mingling of the gabbro with the "granulitic" portion of the hornblende so often forming a gabbro-hornblende-schist, as at the Balk and Lean Water.

The lesson of the dyke would yet further seem to teach us that however much subsequent dynamic action may have affected these Lizard rocks, their strongly contrasted varieties are much less due to this cause, even when combined with any chemical change which might arise therefrom, than to a highly heterogeneous magma, inter-

mittent in its outbursts, and cooling under widely different conditions, affecting the attraction or repulsion of its mineral constituents. The whole of these Lizard rocks bear the impress of this later mechanical and chemical change, but the broader features due to these original and subsequent causes should, I think, be distinctly separated and clearly recognized.

VII.—Preliminary Notes on some Occurrences of Tachylyte in Mull.

By Percy F. Kendall,
Assistant Lecturer on Geology at the Owens College.

The following notes have been compiled in order that, pending the publication of the results of microscopic and chemical examination of the specimens collected, geologists visiting the island may have an accurate localization of the dykes and intrusive sheets bearing glassy selvages observed by the writer and Mr. J. Lomas, A.N.S.S., during a recent visit to Mull. The list includes, for the sake of completeness, three occurrences of tachylyte which have already been described, viz.:—Sorne and Gribun [1] and Ardtun.[2]

The writer has not visited Sorne, but found the tachylyte at Ardtun, and re-discovered that at Gribun, in May, 1887. The last two exhibited certain peculiarities which appear to have hitherto escaped notice, and will be alluded to in the sequel. It is probable that some of the examples will prove upon examination to be more acid than the true tachylytes.

In the table which follows, the word "country" is employed as a convenient term to indicate the rock through which a dyke or intrusive sheet passes, or, briefly, in the miner's sense.

Many dykes which once possessed glassy selvages have undergone a process of decomposition, which, while removing all trace of actual glass, yet, leaves characteristic appearances which are quite unmistakable, though difficult to describe. Among the 200 or 300 dykes examined in Mull, a very large proportion are in this condition.

The tachylyte is occasionally very local in its distribution, and may be present only in small, widely-separated patches.

As a general rule it is thickest on the outsides of the curves of sinuous dykes (*e.g.* A. 12).

The character of the "country" appears to have influenced the formation of glassy selvages, hard and compact rock being a better conductor of heat than loose decomposed or vesicular material has favoured their production. This has been observed in numerous instances of which A. 12 may be taken as the most conclusive. The dyke can be traced across the junction of a sheet of compact basalt with an underlying highly vesicular rock, and thence on into the compact rock again, and it can be seen that in the compact rock the tachylyte is ¼ in. thick, while in the softer rock it is reduced to a mere film. Occasionally, in following up a dyke the tachylyte

[1] Judd and Cole, Q.J.G.S., vol. xxxix. [2] Cole, Q.J.G.S., vol. xliv.

No.	Position.	Bearing (Magnetic).	Character of Dyke or Sheet.	Character of Tachylyte.	Character of "Country."	Remarks.
S. 1.	About 200 yards S.W. of Pier at Salen, Mull.		Intrusive sheet, ? thickness. Vesicular in median part.	Greenish to black. About $\frac{1}{4}$ in. thick.	Mostly compact, but varying with position of sheet.	The sheet is quarried for road metal near the road.
S. 2.	Port Mòr, Ardmòr, Salen. Behind Port Mòr House.	General.*	Dyke 4 feet thick, fine-grained pyritous basalt.	$\frac{1}{8}$-$\frac{1}{4}$ in. thick. Black. Soft (?).	Compact ? felsite.	The specimens are as a rule very soft, and therefore I mark this as doubtful.
S. 3.	Port Bean near "y" of "Salen Bay" on 1 in. map.	N. 4° W.	Small string parallel to a large dyke.	A thin and local film. Black and lustrous.	Compact.	
S. 4.	About 10 yards E. of old cottage, Rudh 'a Ghuail, Salen.	Nearly due N.	Dyke 3 ft. 6 in. wide. Fine transverse columns.	$\frac{1}{4}$ in. thick. Greenish. Soft (?).	Compact.	
S. 5.	20 yards E. of S. 4.	N. 18° W.	Dyke about 5 ft. wide. Sinuous with strong rhomboidal jointing.	Thin, with dull lustre, and very local.	Highly amygdaloidal.	There are layers of infiltration matter between selvage and "country."
S. 6.	E. of Salen Pier—runs under eastern corner of waiting room.	Runs between Beinn na h'Uaigh and Beinn Chreagach.	Dyke with many parallel strings.	$\frac{1}{8}$ in. thick, but thicker in angles. Black and lustrous.	Compact, with porphyritic felspars.	
S. 7.	7 feet E. of S. 5, of which it is probably a branch connected by a small bridge-like intrusive sheet.	Same as S. 5.	Dyke 2 ft. 5 in. wide.	$\frac{1}{8}$ in. thick. Black to green.	Same as S. 5.	There are clear traces of an intrusive sheet adhering to the "country" between S. 5. and S. 7.
K. 1.	Loch na Keal, western end of first field W. of Kellon Wood and on shore opposite.	*Dip* 20° to W.	Intrusive sheet of columnar basalt 18 in. to 2 feet thick with tachylyte top and bottom.	Black, lustrous, upwards of $\frac{1}{4}$ in. thick.	Compact amygdaloidal basalt.	The columns are used as a parapet to road beside Kellon Wood.
K. 2.	N. side of Loch na Keal to W. of Sgeir Maldaig and to E. of "16."	N. 17° W.	Dyke 5 ft. 9 in. wide.	Black, lustrous. $\frac{1}{4}$ in. thick.	Amygdaloidal basalt.	
K. 3.	Intersected by K. 2.	N. 20° W.	Dyke 14 in. wide.	Black, lustrous.	"	
K. 4.	30 yards E. of K. 2.	Parallel to K. 2.	Dyke 8 in. wide.	"	"	
L.P.	Where telegraph wires cross road 300 yards beyond second milestone from Tobermory to Loch Peallach.	Parallel to Sound of Mull.	Dyke of magma basalt with pyrites in joint-planes. Columnar and platy.	Black. Perfect vitreous lustre.	"	Near the road the "country" is rotten, and the tachylyte thin and soft; but further in the "country" is hard and the tachylyte good.

T. 1.	Tobermory Burn—below top fall, just opposite a bye-road.	N. 7° W.	Dyke with columnar jointing. Magma basalt with a little augite.	Black, lustrous.	Compact basalt.	Found by Butler & Kendall, May 1887. A small kernel of tachylyte occurred within the dyke about 6 in. from selvage.
T. 2.	About 10 yards below T. 1.	N. 5° W.	Dyke about 8 in. wide.	Thin and local.	,,	
T. 3.	About 2 yards below T. 2.	N. 5° W.	Dyke 9 in. wide.	,,	,,	
Rn. G.	Rudha nan Gael. Cliff just behind Coastguard Station.		Dyke 3 ft. 6 in. wide. Magma basalt with porphyritic labradorite.	Lustrous, black. Nearly ¼ in. thick.	Hard amygdaloidal basalt.	Found by Butler & Kendall, May 1887. Block on the shore fallen from dyke visible in cliff.
E. 1.	W. side of Erray Burn (between lighthouse and Bloody Bay).	Parallel with Sound of Mull.	Dyke about 3 ft. wide. Coarse grained basalt with minute amygdules and eroded labradorite crystals 2 in. long	Lustrous, black. About ¼ in. thick.	Rather decomposed columnar basalt.	Found by Butler & Kendall, May 1887.
E. 2.	E. side of Erray Burn.	,,	Dyke of fine-grained basalt 8 feet wide.	Much decomposed. Black, with resinous lustre. Firmly adherent to dyke.	,,	
G. A.	Glen Aros, ¼ mile above bridge and 100 yards E. of cutting showing spheroidally weathered basalt.	N. 5° W.	Dyke of pale green rock with minute amygdules and some large mica crystals. 26 in. wide.	Very dark green. 2¼ in. thick, passing into spherulitic structure internally.	Basalt dyke in spheroidally weathered basalt.	This appears to be a case of "dyke-in-dyke."
A. B.	Aros Bridge, just behind 1st house on road to Tobermory.	N. 2° W.	Dyke of porphyritic basalt, 7 feet wide. Much broken up.	Very thin and local. Black and lustrous.		
A. 1.	Immediately behind Aros Hotel and passing E. window.	N. 20° W.	Dyke of magma basalt, 5 feet thick.	Greenish to jet black. ½ in. thick.	Compact basalt.	The *average* direction would probably prove about N. 5° W.
A. 2.	Seaward side of Aros Hotel.	Towards Beinn Chreagach.	Sinuous dyke 20 in. wide. In places very amygdaloidal.	Black and lustrous, coating the dyke in broad patches where the "country" is worn away.	Coarse amygdaloidal basalt.	
A. 3.	Aros Hotel just N. of creek where boats are drawn up.	N.W.	Many small string-dykes, parallel to a large one. The strings are about 1 in. wide and are vesicular down middle.	Very thin.	Coarse basalt.	The strings contain large felspar crystals.
A. 4.	Shore N. of Aros Hotel, 70 yards S. of 2nd wall.	N. 3½° W.* Strikes large island in Sound.	Dyke 15 in. thick.	Thin, lustrous.		
A. 5.	At 2nd wall N. of Aros Hotel.	N. 15° W.	Dyke 4 feet wide. Porphyritic basalt.	Black and lustrous. Thin, local.	Compact basalt.	The dyke runs like a wall for a long distance. The tachylyte is best seen on E. side a few yards from the wall.

* Probably about N. 5° W.

No.	Position.	Bearing (Magnetic).	Character of Dyke or Sheet.	Character of Tachylyte.	Character of "Country."	Remarks.
A. 6.	200 yards N. of A. 5. and 50 yards N. of a wall with wire fence.	N. 26° W.	Dyke with many branches to the S. 8 feet wide at Max.	Black, lustrous. On one branch which thins to nothing, it occurs on both ends of columns.	Compact basalt, much shattered.	
A. 7.	A little N. and seaward of A. 6.	N. 25° W.	Dyke 4 feet wide of coarse vesicular basalt. Breaks to Northward into 8 branches.	Very thin.	"	
A. 8.	Nearly parallel to A. 9, and displaces it by crossing.	Strikes for Beinn Bhear-nach.	Dyke 4 feet wide. Fine-grained basalt weathering sharply.	Best seen at contact with A. 9. Thick.	Compact basalt.	
A. 9.	Allt na Criche; crosses 1st fence N. of cottage.	N. 35° W.	Dyke 8 feet thick. Weathers into rounded masses. Coarser than A. 8.	Bright lustre.	Compact amygdaloidal basalt.	This dyke can be traced to the road from Salen to Tobermory, about 100 yds. S. of milestone "Sal. 3."
A. 10.	Crosses next stone wall to N. of A. 9.	N. 10° W.	Dyke 2 feet wide.	Black, lustrous. Strings of tachylyte penetrate the "country."	Very tough amygdaloidal basalt.	
A. 11.	Between A. 10 and next wire fence to N.	N. 5° W.	Dyke 8 feet wide. Basalt with very large felspars.	Black, lustrous.	Rotten amygdaloidal basalt.	
A. 12.	Strikes shore a few yards beyond wire fence N. of A. 11.	N. 23° W.	Dyke 3 ft. 6 in. wide with parallel composed entirely of tachylyte.	Black, lustrous, $\frac{1}{4}$ in. thick. Thickest on convex side of bends in dyke.	Compact, somewhat soft basalt, resting on decomposed, highly amygdaloidal basalt.	The wire fence alluded to runs up to road 15 yards from milestone "Sal. 3." Where the dyke is in contact with the amygdaloidal rock, the tachylyte is very thin.
A. 13.	30 yards N. of A. 12.	Parallel to A. 12.	Dyke 1 foot wide thinning right out to southward.	Greenish to black. Lustrous.	Compact amygdaloidal basalt.	*Note.*—The dykes A. 1 to A. 13 are given in regular sequence along the shore from S. to N.
A. 14.	N. shore of Port nam Buitsichean 20 yards W. of bye road to Tobermory.	N. 25° W.	Dyke 5 feet wide. Bifurcates and re-unites. Very coarse and vesicular in median portion.	Thin, black, and lustrous.	Coarse compact amygdaloidal basalt, with lustrous brown crystals.	
A. 15.	Apparently cut by A. 14 to seaward.		Dyke 3 feet wide.	Thin.	"	
A. X.	On road from Salen to Tobermory beyond second milestone and 20 yards from turning to Ledmore Loch Frisa.	N. 15° W.	Dyke 5 feet wide.	Black, lustrous.		The specimens obtained *in sitû* were poor though unmistakable, but on the wall intersecting the dyke were fine examples.
T.R. 1.	On same road where the 400 contour-line crosses between 3rd and 4th milestone from Tobermory.	N. 15° W.	Dyke.	Black, lustrous; about $\frac{1}{8}$ in. thick.		

T.R. 2.	On same road, a little nearer to Tobermory than 3rd milestone.	N. 20° W.	Dyke. Contains large felspars like those in A. 11 and E.B. 1.	½ in. thick. Greenish. Includes large felspars.	Compact basalt.	Dyke and "country" are worked for road-metal.
T.R. 3.	On same road, a few yards from gate "Upper Druimfin."	N. 5° W.	Dyke 4 feet wide.	Thin.	Very compact and adherent to dyke.	
K.R. 1.	On summit of road from Salen to Killichronan.		Intrusive sheet exposed from some distance in roadside. Marked platy jointing.	Black to greenish. Very local.	Hard and compact.	The specimens were found after repeated searches close to the intersection of a large dyke. We were led to re-examine by finding a block with tachylyte on the Survey cairn on the level stretch of road nearer to Salen.
K.R. 2.	A few yards W of K.R. 1, where intrusive sheet dips under talus, and before its reappearance to W.	General bearing.	Small dyke 2-5 inch wide.	Local. Greenish to black.	Compact basalt.	
C.M. 1.	Creag Mhòr, S. side of Loch na Keal. About letter "r" in "Creag" 1 in. map.		Probably from intrusive sheet about 1 foot thick. Fine-grained basalt with iron pyrites. Columnar.	Black, lustrous.	Compact, coarse-grained basalt.	A dyke and at the least six intrusive sheets are visible in the cliffs. The specimens were from fallen blocks.
C.M. 2.	Fallen block at 1st bridge from Creag Mhòr towards Gribun.			Black, lustrous.	"	
G.	Pass of Gribun about letter "a" in "Balmeanach" on 1 in. map, and 100 yards S. of gate.	? about N. 40° W.	Dyke 3-8 in. wide. Bifurcates and re-unites.	Black and highly lustrous. Max. 1 in. thick. Runs into the vesicles in "country."	Rotten, pulverulent, and amygdaloidal, but for a foot on each side of the dyke very hard and compact.	Described by Judd and Cole, Q.J.G.S. vol. xxxix. Rediscovered by Butler and Kendall, May, 1887.
T.	Torrens, Loch Scridain.			Black and lustrous.		The specimen was found by Mr. F.H. Butler, May, 1887, upon a wall to W. of Torrens. Time would not permit of its being traced to its source.
A.B.	Ardtùn Brae.		Intrusive sheet.	Black, highly lustrous. Max. 5 in. thick. Runs down between columns of underlying basalt for a distance of 4 feet.	To N. compact non-vesicular, and to S. amygdaloidal basalt.	Described by Cole, Q.J.G.S. vol. xliv. Discovered independently by Duke of Argyll (?), Mr. Koch, Mr. Cole, and Butler and Kendall (May, 1887).
B.C.	Summit of Beinn Chreagach, near S. side.		Intrusive sheet 10 in. thick.	Greenish. Dull lustre.	Very coarse gabbro.	The rock has rather the appearance of an intermediate rock.
	Sorne, 3 miles N.W. of Tobermory.		Dyke.	¼ inch thick.		Described by Judd & Cole, Q.J.G.S. *loc. cit.*

gives place to a black or greenish substance having a hardness of about 2.

Several cases have been noted in which small strings have been given off consisting wholly of tachylyte, for example strings descend from the Ardtun intrusive sheet between the colums of the basalt "country" to a distance of, at the least, four feet.

A good test for intrusive sheets when the stratigraphical evidence is inconclusive has long been a desideratum, and it may be that certain peculiarities in those observed in Mull may prove really diagnostic when a sufficient number of examples have been examined to justify generalisation.

The Ardmòr intrusive sheet (S. 1) was recognized as such in the first instance by the extraordinary sharpness of the plate-like columns and subsequently the determination was confirmed by the discovery of the tachylyte selvages. This sheet is amygdaloidal *in the middle* and the same peculiarity is presented by other intrusive sheets, and also by many dykes (*e g.* G. A.) in Mull, while, as is well known, lava-streams are vesicular top and bottom.

In conclusion, the writer desires to express his conviction that, when Mull comes to be fully surveyed, dykes with tachylyte selvages will be numbered by hundreds, or, it may be, even by thousands.

Note by Bernard Hobson, Esq., B.Sc.—On the coast, between tide-marks, to East of the "principal ravine" of Mr. Starkie Gardner, at Ard Tun, are two intrusive sheets, each about one foot thick, one above the other, with only 2 or 3 inches between them. They are intruded into the basalt, and each sheet bears a thick selvage of tachylyte both above and below, the mass of the sheet being characterized by large spherulites, clearly visible to the naked eye, especially when the rock is wet. The sheets are irregularly columnar and their surfaces where exposed by erosion of the "country," present a striking appearance owing to their brilliant glassy blackness.

VIII.—Notes on the "Monian System" of Professor Blake.

By Ch. Callaway, D.Sc., F.G.S.

As Professor Blake, in his elaborate paper in the Quarterly Journal of the Geological Society for August last, makes frequent reference to my work in Anglesey, I may perhaps be permitted a brief comment. I do not intend to enter upon an elaborate controversy, since I prefer, now that the two views of the district have been published, that those interested in the matter should visit the ground, and judge for themselves. Nevertheless, it is well that the salient points of agreement and difference between the two readings should be placed in a clear light.

On the fundamental question—the Archæan age of the bulk of the Anglesey crystallines and altered slates—Prof. Blake is at one with Dr. Hicks, Prof. Bonney, and myself; but he differs from those geologists who place a part of our Archæan in the Ordovician, and

from Sir A. C. Ramsay, who referred the whole to post-Archæan times. The chief difference between Prof. Blake and myself is that whereas I subdivide the Archæans of Anglesey into two groups, which, to avoid theory, I simply described as *Gneissic* and *Slaty*; he desires to lump them together as one system called *Monian*. This divergence of opinion is not very serious. If stratigraphical links between two formations can be detected, it may (and it may not) be desirable to give them one name. The question is, Are Prof. Blake's links strong enough?

Before answering this query, I should like to indicate one or two additional points on which I am happy to express acquiescence with Prof. Blake. When I first studied the rocks of Anglesey, nearly ten years ago, I held the current views on metamorphism. Most geologists of that day believed that mineral banding in schists generally followed an original sedimentation, and the evidence then available tended to support that view. Accordingly, when I saw granite interbanded with schists in parallel beds, I followed Dr. Hicks and Prof. Bonney in concluding that this granite was of metamorphic origin. We have since then learned much of the wonderful effects produced by pressure. I have accordingly studied some of my former sections in the light of the new theories, and have adopted a different interpretation of some of the old facts. I hold that the granitoid mass in the centre of the island is truly igneous, and sends apophyses into the adjacent schists; also that some of these schists themselves are igneous rocks, diorite and felsite, which have been metamorphosed by mechanical and chemical energies. It will be seen that I thus go beyond Prof. Blake himself, who, as I understand him, assigns a plutonic igneous origin only to the granite and the modified diorite. My views were given in outline to the British Association in 1887, before I knew that Prof. Blake had come to similar conclusions.

How far do the new theories affect my old work? Simply thus: my time-succession of the Older Archæans becomes a mineral succession. The mapping and sections remain substantially the same, but the element of time must be transferred from a supposed order in deposit to the order in which the igneous masses were extruded and to the period or periods of their metamorphism.

My descriptions of the Newer Archæan rocks are in the main accepted by Prof. Blake; but he has added many observations made in districts not studied by me. These, if confirmed, will prove to be of much interest.

A little more care would have saved Prof. Blake some trouble. He elaborately attempts to refute my (supposed) opinion that the rocks of Paris Mountain are of Archæan age. It is true that in my map I placed this mass in the Archæan, because it was necessary to put it somewhere, and the evidence seemed to me to turn a little in favour of the Archæan view; but in the text (Quart. Journ. Geol. Soc. May, 1881, pp. 222 and 224), I expressly declined to assign any age to the rocks, and to that scepticism I still adhere.

To return to our main question: Is there only one Archæan

system in Anglesey? In arguing for two groups, I assigned some importance to the evidence of included fragments. Prof. Bonney (*supra*, p. 235) states that the Llanfechell Grit (Newer Archæan) contains "detrital materials almost certainly derived from the older gneissic and schist rocks of this part of North Wales." Again, in the Quarterly Journal for 1884, p. 576, I contended that the basement Palæozoics near Tywyn contained fragments of slaty rock, and that a mass of the same slate *in situ* included rounded pieces of the adjacent granite. Prof. Bonney, after microscopic examination, unhesitatingly confirmed my identifications. Prof. Blake, however, contests both points. He says that none of the fragments in the Llanfechell Grit are "indubitably schists." Prof. Bonney, at my desire, has re-examined the rock, and thus writes:—

"My description is accurate. There are several fragments of a very fine-grained schist consisting of quartz and a flaky green mineral, which is either chlorite or an altered biotite, so far as I can make it out. These much resemble some of the finer-grained schists of Anglesey in my collection. Of course, in some crystalline schists one cannot say how much of the structure may be due to mineral segregation, or to veining subsequently modified; but in the ordinary sense of the words these are bits, not of vein substance, but of schist. Probably Prof. Blake was unlucky with his specimen." In reference to the last suggestion, I may say that both professors have studied *the same* slide.

The slate near Tywyn is regarded by Prof. Blake as a "diabase." The slides of this slate originally described by Prof. Bonney have been again examined by him. This is what he says about them:—

"My descriptions are accurate. There must be some misunderstanding about the locality, for I cannot realize the possibility of such a mistake being made as to call this rock a diabase." Prof. Blake[1] appears to have no doubt that his "diabase" is the same as my "slate," and from his description I should think he was right; though his examination of the ground was so incomplete that he did not even find the conglomerate and grit[2] which rest on the eastern side of the granite axis. If then Prof. Blake has rightly identified his "diabase" with my "slate," we are driven to make a choice, on the microscopic question, between him and Prof. Bonney. Prof. Blake will forgive me if I prefer Prof. Bonney's opinion to his.

Having thus disposed of the argument from included fragments, Prof. Blake attempts to prove that there is a passage between my lower and upper groups. It would take a paper of many pages to discuss this point. Whatever there may be in spots I have not visited, I am bound to say that in those districts known to me Prof. Blake's efforts to connect the gneissic rocks with the slaty appear

[1] In a note to p. 483, Prof. Blake has "little doubt" that I sent to Prof. Bonney fragments included in the Palæozoic in mistake for specimens of the rock *in situ*! I make no comment on this suggestion, as I am unwilling to believe it was seriously intended.

[2] Several specimens were described in my paper (Nos. 124, 125, 126).

to me quite unsuccessful. I will give two examples. In the Llangefni "syncline," Prof. Blake wishes to construct a sequence from the grey gneiss up to the Llangefni conglomerates. He admits a fault somewhere to the east of the gneiss; but says that "the throw of the fault *may*[1] not be great, and the lowest rocks exposed (to the east of the fault) *may* not be far above the grey gneiss." Again: the rocks to the east of the fault pass *downwards* into the Llangefni[2] conglomerate; but Prof. Blake comes to the conclusion that this order is inverted, and he offers as his main proof the proposition that if there is no inversion, the order is different from that which obtains elsewhere. But I am not at all satisfied what is the normal succession, and I do not think that Prof. Blake has established it. In this district, then, Prof. Blake's demonstration rests upon two hypotheses and an unproved inversion.

Again, in the area south-west of Mynydd Llwydiarth, our author is "led to see there is an undisturbed succession" between my Gneissic and Slaty groups, although he admits that the ground is "broken." It is broken, with a vengeance, and any attempt to mend it into "an undisturbed succession" is doubtful in the extreme.

If Prof. Blake's "Monian System" is of any value, it must be applicable to other regions. Its author applies it to Shropshire. The Longmyndian[3] group is referred to "Upper Monian"; the Uriconian and Malvernian are lumped together as "Middle Monian." The Longmyndian is placed in the "Upper Monian," because it is correlated with the Bray Head Series (elsewhere affirmed to be Upper Monian) by its fossils. This fossil evidence is entirely new to me. When we have seen it, we shall be able to judge of its value. As the Longmyndian is largely derived by denudation from the Uriconian, there must be a considerable gap between the two. Again, there must be a marked break between the Uriconian and the Malvernian, for the latter underwent its metamorphic change (by whatever means) before the Uriconian period, and its dominant strike is discordant to that of the newer series. And if the Malvernian is only "Middle Monian," where shall the "Lower Monian" be found? But to those who know the Shropshire rocks, the attempted correlations will appear so unsubstantial that any argument I can urge will almost seem like beating the air.

If the Longmyndian is Archæan, Shropshire and Malvern will furnish us with a threefold subdivision of the Archæan rocks, the Malvernian, the Uriconian, and the Longmyndian; and I submit that these will make far better types than the battered fragments of Archæan rock in Anglesey. If the Uriconian is Pebidian, of course Dr. Hicks's term has priority.

[1] The italics are mine.

[2] Prof. Blake calls this an "agglomerate." As the contained fragments, which are rounded, are mainly quartzite, with grits and hornstone in smaller proportion, I do not see the applicability of the term.

[3] I used this name for the Longmynd series in a paper contributed to the Transactions of the Shropshire Archæological Society in 1887, on the ground that its Cambrian age was doubtful.

NOTICES OF MEMOIRS.

I.—Note on the Occurrence of Leucite at Etna.[1] By H. J. Johnston-Lavis, M.D., F.G.S.

SOME years since, whilst on a visit to Etna, my attention was drawn to some superficially placed tuffs of a chocolate to a coffee-brown colour. In these tuffs, near the Casa del Bosco, are observable included pieces of scoriaceous lava which to the naked eye are evidently leucitic; that mineral occurring in well-formed crystals attaining to some millimetres in diameter, and brilliantly white as the result of fairly advanced kaolinization. In consequence of this change the rock is excessively friable, and, therefore, difficult to sectionize. A section of it, however, was exhibited at the meeting, and also two photo-micrographs therefrom. In these it will be seen that kaolinization has extended along the fracture planes of the leucites, whilst the beautifully formed pyroxene crystals are unaltered, and the triclinic felspars are fairly in a normal condition. The base is a microlitic net-work of felspar and pyroxene, together with beautifully minute cubes and octahedra of magnetite, rendering the substance intervening between the crystals almost opaque, even in thin sections. The pyroxene is often enveloped in a casing of leucite, as at Vesuvius, Roccamonfina, etc., confirming what I have asserted in other places, namely, that leucite is one of, if not the latest mineral to crystallize.

I regret that I have not the opportunity of investigating the question of the origin and age of this rock more completely, as on writing to my friend Prof. O. Silvestri, inquiring if leucite had yet been encountered at Etna, I received a categorical answer in the negative which, coming from such an authority, must be taken as conclusive as to the rarity of leucitic rocks being produced from Etna.

The discovery of this mineral at Etna is what one would have looked for, knowing as we do its wide distribution in nearly all the other late basic volcanoes of Italy.

II.—An Igneous Succession in Shropshire.[1] By W. W. Watts, M.A., F.G.S., Fellow of Sidney College, Cambridge.

THE author described the succession of igneous rocks in the Shelve and Corndon district of Shropshire. 1. There is a series of *andesitic* ashes interbedded at two principal horizons in the Ordovician sequence. These have a percentage of silica varying from 63–60. 2. Then come three sets of intrusive masses. *a. Andesites* (59–54 per cent. of silica); these are intruded into Ordovician rocks and never touch the Silurian of the district. *b. Dolerites* (49–47 per cent. of silica), which are post-Silurian in date. *c. Picrites* (40–34 per cent. of silica), of later date. There are undoubtedly rocks intermediate in age and composition, but it is difficult to be quite sure of this where the differences in composition are so slight. One,

[1] Read before Section C. (Geology) British Association, Bath, September, 1888.

however, the dolerite of Llanfawr, is a very basic dolerite, coming between the normal dolerites and picrites. In minerals a similar transition is to be noted. The andesites are rich in hypersthene, the dolerites rather richer in augite, while olivine and brown mica occur in the picrites. The author believed that the felspars became most basic in the more basic rocks, but he had not yet fully investigated this point. Another curious point was that the mineral aggregates in the glomero-porphyritic andesites are practically pieces of the ophitic dolerites. The determination of the specific gravities gave a similar sequence, the lighter rocks having been intruded last. Each of the irruptive rocks occurred in laccolites along the main anticline of the district, and also in the dykes and fault lines.

III.—On the Lower Carboniferous Rocks of Gloucestershire.[1]

By E. Wethered, F.G.S., F.C.S., F.R.M.S.

In Gloucestershire there are two Coal-fields, namely, that of Bristol and the Forest of Dean. The Carboniferous Limestone Series of Gloucestershire was long ago divided by Sir H. De La Beche as follows:

Upper Mixture of Sandstones.

	Clifton. Feet.	Forest of Dean. Feet.
Marls and Limestones	400	146
Central Portion...	1438	480
Lower Shales	500	165
	2338	791

The author has proposed som. detailed alterations with regard to the Bristol Coal-field which are stated in the Quart. Journ. Geol. Soc. for 1888, p. 187, but the above divisions have been generally accepted under the terms Lower Limestone Shales, Carboniferous Limestone, and Upper Limestone Shales. Professor Hull has given a classification of the Carboniferous Series throughout the country (Quart. Journ. Geol. Soc. 1877), based on the various stages which occurred during the deposition of the rocks. The author supports the principle of that classification, and is of opinion that the Lower Carboniferous rocks of Gloucestershire might be correlated with the same formation in the North of England. If this could be done, it might be possible to adopt terms for the respective stages which would apply to the North and South of England, and thus avoid the complication of terms now in use.

The author then recited the stages which occur in the Carboniferous Limestone of Gloucestershire. Above the Old Red Conglomerate there appears a series of sandy beds which are best developed in the Forest of Dean. These consist of micaceous green shales and red, purple and yellow sandstones. Some are calciferous and readily effervesce when treated with acid. No fossils have been found, but quartz pebbles occur in some of the beds.

The strata just referred to pass up into limestone and shales, the

[1] Read before Section C. (Geology) British Association, Bath, September, 1888.

so-called Lower Limestone Shales. In the Forest of Dean the limestones are largely made up of the valves of Ostracoda, among which the following have been determined: *Kirkbya variabilis*, *K. plicata*, *Cytherella extuberata*, *Bythocypris sublunata*, and *Darwinula berniciana* (?). Among the other fossils which are numerous may be mentioned *Athyris Royssii*, *Rhynchonella pleurodon*, *Encrinites*, and *Polyzoa*. Among the latter the following have been determined: *Rhabdomeson gracile*, Phill., and *Fenestella tuberculocarinata*, Ether. jun. In the Lower Limestone Shales of the Bristol Coal-field Ostracoda are not so plentiful, though in some beds the valves of these small Crustacea are numerous. *Rhynchonella pleurodon*, *Athyris Royssii*, *Productus*, *Spirifera*, Crinoids, and Polyzoa occur. At Clifton the Lower Shales are followed by a Crinoidal Limestone known as the Black Rock, which is about 490 feet thick and is not represented in the Forest of Dean. The Black Rock series are followed by 70 feet of Dolomite, and then by about 100 feet of white oolitic limestone which the author regards as the true base of the Middle or Carboniferous Limestone. The author has grouped the Lower Limestone Shales with the Black Rock under the term Lower Limestones, and he considers the stage to occupy the horizon of the Tuedian and Calciferous series of the North of England and Scotland. As to the sandy beds which lie between the Old Red Conglomerate and Lower Limestone Shales, the author regards them as the equivalent of the lower portion of the Transitional series of Phillips and the Calciferous of Scotland. The true upper limits of the Old Red Sandstone should be drawn at the Old Red Conglomerate.

As to the Middle Limestone there can be no doubt that it is the equivalent of the Carboniferous Limestone as generally understood, a term which the author thinks objectionable, and he would term the whole series Carboniferous Limestone. The Middle Limestone is largely made up of *Foraminifera* and *Calcisphæra*, but Corals, Polyzoa, Crinoids, and shells occur, sometimes in quantity. In the Forest of Dean the Middle Limestone is extensively dolomitized.

Coming to the Upper Limestones; at Clifton it is difficult to draw the line at which the series should commence, as there is little alteration in the structure from that of the Middle Limestones. Corals are more numerous, coarse oolitic beds appear, and the beds become mixed with Millstone-grit. In the Forest of Dean the upper stage is well and clearly defined by two characteristic limestones known as 'Crease' and 'Whitehead.' The former of these has become partially crystallized, but in some beds shells of *Productus* are numerous, and also *Calcisphæræ*.

The Millstone-grit is about 900 feet thick in the Bristol Coal-field, and is a hard, slightly pink-coloured quartzite. In the Forest of Dean it is about 270 feet, and is a loose yellow, red and mottled sandstone made up of well-rounded grains of quartz. The lowest beds are argillaceous, and contain remains of *Lepidodendra*.

I.—NOTES ON THE GEOLOGICAL HISTORY OF THE RECENT FLORA OF BRITAIN. By CLEMENT REID, F.G.S. [Annals of Botany, vol. ii. No. vi. August, 1888.]

WE are glad to be able to direct attention to this important paper, which records the plants obtained in this country from Preglacial, Interglacial, and Postglacial deposits. By means of investigations, which Mr. Reid has for some years carried on with great assiduity, he hopes to show what plants are truly native, what variations of climate they show, and the geographical distribution of the living species in past times. In the meanwhile he publishes an account of the material at present obtained, and this it is hoped may stimulate others to pay attention to the subject of the geological history of the Recent flora.

The Preglacial deposits from which plants have been obtained, belong to the Cromer Forest-bed, which underlies all the Glacial deposits, and forms the highest portion of our Pliocene formation. The Interglacial deposits include beds which underlie Boulder-clay, but are newer than the Cromer Forest-bed, and with them is classed, for the sake of convenience, the bed with Arctic plants (discovered by Dr. Nathorst) that underlies the lowest Boulder-clay in Norfolk. The Postglacial group includes the "submerged forests," and contemporaneous upland deposits; raised marine deposits, like the Clyde beds; and beds with Arctic plants, lying directly above the latest Boulder-clay of the district. Only those species are included that date from a period previous to the Roman occupation.

The different localities from which Interglacial plants have been obtained are nearly all in Scotland, and the most interesting deposits are those found at Redhall and Hailes quarries, about three miles from Edinburgh, where a large collection of specimens has been obtained by Mr. James Bennie.

The following is a list of the species recorded by Mr. Reid:—

SPECIES.	Pre-glacial.	Inter-glacial.	Post-glacial.
Thalictrum minus? Linn.	x		
——— *flavum*, Linn.	x		
Ranunculus aquatilis, Linn.	x	x	
——— *sceleratus*, Linn.	...	...	x
——— *flammula*, Linn.	...	x	x
——— *lingua*, Linn.	...	x	
——— *repens*, Linn.	x	x	x
Caltha palustris, Linn.	...	x	
Nuphar luteum, Linn.	x	...	x
Lychnis diurna, Sibth.	...	x	
——— *flos-cuculi*, Linn.	...	x	x
Stellaria aquatica, Scop.	x		
——— *media*? Linn.	...	x	
Oxalis acetosella, Linn.	...	x	
Prunus communis, Huds.	x		
——— *padus*, Linn.	...	x	x
Rubus idæus, Linn.	...	x	x
——— *fruticosus*, Linn.	x	x	
Potentilla tormentilla? Neck.	...	...	x
——— *comarum*, Linn.	...	x	

Species.	Pre-glacial.	Inter-glacial.	Post-glacial.
Poterium officinale, Hook.	x		
Hippuris vulgaris, Linn.	x	x	
Myriophyllum spicatum, Linn.	x	x	
Trapa natans, Linn.	x		
Apium nodiflorum, Reich.	...	x	
Carum carui, Linn.	...	x	
Œnanthe lachenalii, Gmelin.	x	...	x
Peucedanum palustre, Mœnch.	x		
Cornus sanguinea, Linn.	x	...	x
Sambucus nigra, Linn.	...	x	x
Valeriana officinalis, Linn.	...	x	
Eupatorium cannabinum, Linn.	...	...	x
Bidens cernua, Linn.	...	x	
——— *tripartita*, Linn.	x		
Matricaria inodora, Linn.	...	x	
Senecio sylvaticus, Linn.	...	x	
Carduus lanceolatus, Linn.	x	x	
——— near to *palustris*, Hoffm.	...	x	
Lapsana communis, Linn.	...	x	
Leontodon autumnalis, Linn.	...	x	
Taraxacum officinale, Web.	...	x	x
Sonchus arvensis, Linn.	..	x	
Arctostaphylos uva-ursi, Spreng.	...	...	x
Menyanthes trifoliata, Linn.	x	x	x
Myosotis lingulata, Lehm.	x		
Bartsia odontites, Huds.	...	...	x
Pedicularis palustris, Linn.	...	x	
Lycopus europæus, Linn.	x		
Thymus serpyllum, Linn.	...	...	x
Prunella vulgaris, Linn.	...	x	
Stachys palustris, Linn.	x	x	
Galeopsis tetrahit, Linn.	...	x	
Atriplex patula, Linn.	x	x	x
Suæda maritima, Dum.	x		
Polygonum aviculare, Linn.	...	x	
——— *persicaria*, Linn.	...	x	
Rumex maritimus, Linn.	x		
——— *obtusifolius*, Linn.	...	x	
——— *crispus*, Linn.	x	x	x
——— *acetosella*, Linn.	x		
Euphorbia helioscopia, Linn.	...	x	
——— *amygdaloides*, Linn.	x		
Ulmus, sp.	x	...	..
Betula alba, Linn.	x	x	x
——— *nana*, Linn.	...	x	x
Alnus glutinosa, Linn.	x	x	x
Corylus avellana, Linn.	x	x	x
Quercus robur, Linn.	x	x	x
Castanea sativa, Mill.	...	...	?
Fagus sylvatica, Linn.	x		
Salix cinerea, Linn.	x	...	x
——— *repens*, Linn.	...	...	x
——— *herbacea*, Linn	...	x	
——— *polaris*, Wahlb.	...	x	
Empetrum nigrum, Linn.	...	x	
Ceratophyllum demersum, Linn.	x	..	x
Taxus baccata, Linn.	x	..	x
Pinus sylvestris, Linn.	x	x	x
——— *abies*, Linn.	x		

Species.	Pre-glacial.	Inter-glacial.	Post-glacial.
Juncus, sp.	...	x	
Sparganium ramosum, Curtis.	x	x	x
Alisma plantago, Linn.	x	x	
Potamogeton rufescens, Schrad.	...	...	x
——— *heterophyllus*, Schreb.	x	x	
——— *lucens*, Linn.	x		
——— *prælongus*, Wulf.	x		
——— *perfoliatus*, Linn.	...	x	
——— *crispus*, Linn.	x		
——— *pusillus*, Linn.	..	x	
——— *trichoides*, Cham.	x		
——— *pectinatus*, Linn.	x	x	
Zannichellia palustris, Linn.	x	x	
Eleocharis palustris, R. Br.	...	x	
Scirpus pauciflorus, Lightf.	x	x	
——— *cæspitosus*, Linn.	x		
——— *fluitans*, Linn.	x		
——— *setaceus*, Linn.	...	x	
——— *lacustris*, Linn.	x	x	
——— *maritimus*, Linn.	...	...	x
Eriophorum angustifolium, Roth.	x		
Cladium germanicum, Schrad.	x		
Carex dioica, Linn.	...	x	x
——— *echinata*, Murr.	...	x	
——— *canescens*, Linn.	...	x	
——— *panicea*, Linn.	...	x	
——— *flava*, Linn.	...	x	
——— *paludosa*, Good.	x		
——— *riparia*, ? Curtis	x		
——— *rostrata*, Stokes	...	x	
Anthoxanthum odoratum, Linn.	...	...	x
Agrostis, sp.	...	x	
Holcus lanatus, Linn.	...	x	
Phragmites communis, Linn.	x	...	x
Poa trivialis, Linn.	...	x	x
Osmunda regalis, Linn.	x		
Isoëtes lacustris, Linn.	x	x	x

Nymphæa alba, Linn., from the Cromer Forest-bed *Cratægus oxyacantha*, Linn., Postglacial; *Fraxinus excelsior*, Linn., Postglacial; *Scutellaria galericulata*, Linn., Interglacial; and *Hordeum distichum*, Linn., have been recorded, but Mr. Reid considers the evidence too doubtful to justify their insertion in the above list.

It should be mentioned that the terms Preglacial, Interglacial, and Postglacial are used provisionally, and for the sake of convenience, because at present it is not always possible to separate the Pleistocene from the Recent deposits. H.B.W.

II.—Geological Survey Memoirs.—(1.) The Geology of North Cleveland. By George Barrow, F.G.S. 8vo. pp. 101. Price 1*s.* 6*d.* (London, 1888.)

In this memoir we have a description of the Yorkshire coast from Whitby to Redcar, and of the northern part of the Cleveland district. Strata from the Red Marls of the Trias to the Kellaways

Rock are described, together with Glacial and Post-glacial deposits; and there are notes on the Cleveland dyke, an augite-andesite, whose intrusion took place probably in Tertiary times.

The Oolitic hills attain an elevation of 1078 feet on Guisborough Moor, while on the coast Boulby or Rockcliff, formed mainly of Lias, is nearly 700 feet high.

The lower beds of the Lias have been proved in borings, but are only exposed at the surface in the "scars" seen at low-tide off Redcar. These beds were, however, described in such detail by Prof. Tate, that our knowledge of the palæontology is very full. The higher beds of the Lower Lias, with *Ammonites Jamesoni*, *A. capricornus*, etc., are briefly described, more detailed descriptions of the strata having been given in the Survey Memoir on the country between Whitby and Scarborough.

From an economic point of view the most important portion of this Memoir is that dealing with the Ironstone Series of the Middle Lias, full details of which are given by Mr. Barrow. In the Upper Lias the Alum industry is now practically extinct, while the introduction of Spanish Jet has almost entirely stopped the local Jet-mining. The *Ammonites* furnish material of much interest. Mr. Barrow observes that a perfect series can be found to show the gradual transition of *Am. communis* to the extreme types of *A. crassus* and *A. Holandrei*: facts which will not be disputed by those familiar with the variable forms obtained in the South of England. The doubtful identification of *A. elegans*, Young and Bird, with *A. concavus*, Sby., is at any rate interesting, while the occurrence of *A. radians* (?), Rein., in the Alum Shale, is also noteworthy.

The variable "Dogger," the base of the Inferior Oolite, occurs on top of the Alum Shale, and is ferruginous and pebbly—the 'pebbles,' it is considered, being waterworn nodules from the Lias. Among other fossils *Rhynchonella cynocephala*, *R. tetrahedra*, and *Terebratula punctata* are recorded from the Dogger in Whitecliff Beck.

The Estuarine Series, grouped with the Inferior Oolite, includes representatives of the Eller Beck Bed and the Grey Limestone Series. The Cornbrash is poorly represented, while the Kellaways Rock is well shown, and yields, among other fossils, *Avicula braamburiensis*, a form characteristic of the marine bands in the Estuarine Series below.

The Drift obliterates all but the most strongly marked geological features of the country. It becomes very thin at heights of 600 feet above sea-level, and disappears altogether above 850 feet. Mr. Barrow concludes, that the ice must have ground over the rocks with no slight force is proved by the fact that at Eston Hill a strip of the Main Seam (Middle Lias Ironstone), some 150 yards long, 50 broad, and 11 feet thick, has been bodily lifted up the face of the hill to a point about 150 feet above its natural outcrop. It is also interesting to learn that the Drift deposits have blocked the old Preglacial valleys and forced the streams to form new channels, which they have cut out through deep gorges in the solid rock, in preference to re-excavating their old course through the Boulder-clay.

III.—Geological Survey Memoirs.—(2.) The Geology of the Country around Lincoln. By W. A. E. Ussher, F.G.S., A. J. Jukes-Browne, B.A., F.G.S., and Aubrey Strahan, M.A., F.G.S. (In Part from Notes by W. H Penning, F.G.S., W. H. Dalton, F.G.S., and A. C. G. Cameron.) 8vo. pp. 218. Price 3*s*. (London, 1888.)

A LARGE area is described in this Memoir, including the country around Tuxford, Gainsborough, Lincoln, Market Rasen, Wragby, and Horncastle.

The rocks exposed range from the Bunter pebble-beds to the Chalk, together with Glacial and Post-glacial deposits.

The various divisions are described in detail, and their chief palæontological features are pointed out. The junction of the Lower and Middle Lias, nowhere well marked, is now usually taken by the Survey at the base of the zone of *Ammonites margaritatus*, and above that of *A. capricornus*. It appears, however, that in Lincolnshire and Yorkshire the two species of *Ammonites* occur sometimes together. While the fossils of the Lias are many of them noted with the accounts of the strata, those from the Inferior Oolite (Basement Beds and Lincolnshire Limestone) and the Great Oolite Series are, with few exceptions, enumerated only in the Appendix, so that we have to turn away from the barren account of the rocks to learn, if possible, the prominent fossils which they yield. From the Inferior Oolite two species of *Ammonites* are recorded, *A. Sowerbyi* and *A. læviusculus*. The Cornbrash, Kellaways Rock, and Oxford Clay appear here, as elsewhere, to be intimately connected.

Ammonites Bakeriæ and *A. macrocephalus* are recorded from the Cornbrash. This formation is separated from the Kellaways Rock by a few feet of black shales, grouped with the latter, although regarded as homotaxial with the "Avicula Shales" or Cornbrash Clay of Yorkshire. The following species are recorded from the Upper Oxford Clay near Bardney, forming an interesting assemblage: *Ammonites perarmatus, A. biplex, A. macrocephalus, A. cordatus, A. plicatilis*, etc.

The Lower Cretaceous or Neocomian rocks include the Spilsby Sandstone and the Tealby Beds. The Spilsby Sandstone contains many derived fossils, while among those regarded as indigenous, are *Ammonites Kœnigi, A. mutabilis*, etc. The overlying Tealby Beds are divided as follows:—

Tealby Limestone.
Tealby Clay.
Claxby Ironstone.

These two groups belong to the Speeton Series, and they rest unconformably on the Kimeridge Clay, and are overlain unconformably by the Carstone.

The Carstone is found to be made up very largely of the rolled and washed débris of the Neocomian clays, or where the Carstone is missing, the Red Chalk is found to contain fossiliferous nodules derived from the same source. Evidence is brought forward to

show that the Carstone and Red Chalk indeed pass upwards one into the other.

The various divisions of the Chalk are described, as well as of Glacial and Recent deposits. Numerous records of well-sections and borings, and an account of mineral springs are given in the Appendix.

IV.—I. ETUDES SUR L'HISTOIRE PALÉONTOLOGIQUE DES ONGULÉS.—II. LE DÉVELOPPEMENT DES EQUIDÆ. III. RHINOCERIDÆ ET TAPIRIDÆ. By MARIE PAVLOW. Bull. Soc. Imp. Nat. Moscou, 1888, pt. 1, pp. 135—180, pls. i. ii.

THE well-known researches of Kovalewsky upon the evolution of the Ungulata are now being continued in Moscow by Madame Marie Pavlow; and the present memoir is the second instalment of results already obtained. The greater portion of the memoir and the plates relate to the development of the Horses; a few pages are devoted to the Rhinoceroses and Tapirs.

Some preliminary remarks upon the earliest Perissodactyles lead to the conclusion that the species already assigned to the so-called *Hyracotherium* are truly referable to three groups:—"1. *Hyracotherium leporinum*, Owen = *Phenacodus leporinus*, characterized by upper molars with six rounded tubercles, and by lower molars with four tubercles connected by feebly marked ribs into two crescents. 2. The other species of *Hyracotherium*, except *H. craspedotum*, Cope, must be placed at the base of the line of Horses. This genus remains characterized by upper molars with six slightly elongated tubercles, of which the contours are less well marked than in the preceding form; lower molars exhibit two distinct crescents, but do not possess the double tubercle (aá, Rütimeyer). Lastly, 3. *Pachynolophus siderolithicum* (= *Hyracoth. siderolithicum*) generically follows the *Hyracotherium* proper, and may be distinguished by the six tubercles of the upper molars being united into two crests, and by the appearance of the double tubercle (aá Rütim.) on the lower molars—a character peculiar to the Equidæ."

A critical review of previous researches upon the evolution of the Horses next follows, and Madame Pavlow concludes that it is most unreasonable to suppose that the Pleistocene Horse of the New World was developed from a line of ancestors independent of that culminating in the modern Horse of the Old World, preferring rather to account for difficulties by a theory of migration. The authoress also adopts the view of Schlosser, that *Palæotherium* cannot be placed in the direct ancestral line of the Horse; and the genus *Anchilophus* is substituted as the most likely immediate predecessor of *Anchitherium*, so far as can be judged from known forms. An interesting discussion of the teeth and limb-bones of *Hipparion* also results in the conclusion that that genus cannot be regarded as a direct ancestor of *Equus*. Madame Pavlow points to the plicated character of the enamel folds and the distinct separation of an antero-internal denticle in the teeth of *Hipparion*, and considers that this genus bears the same relation to the Horse that *Elasmotherium* holds with respect to the Rhinoceros. "The teeth of *Anchitherium*, in

their development, have had no need of passing by the stage of *Hipparion* to arrive at *Equus*; their evolution in this direction has given the form of the teeth of *Meryhippus*, *Protohippus* and *Equus*, in the proper sense of the name; and in this chain, it has not been necessary for any of the essential parts of the molars to disappear in order to re-appear later, or to develop parts completely new and different." *Hipparion*, indeed, is to be looked upon as "a form which became separated from the direct Equine series before the evolution of the *Equus*-type was complete, and perhaps even before *Anchitherium aurelianense*."

A study of the milk-teeth of the successive genera supposed to be ancestral to the Horse seems to lead to at least three conclusions, as follow:—"1. The milk-molars are not a repetition of the premolars of the preceding form, but, on the contrary, foreshadow the premolars of a new form which is to follow; 2. The difference between the milk-teeth and the premolars of one and the same form is greater in proportion to its antiquity; 3. The resemblance between the milk-teeth and the premolars in two successive forms is closer in proportion to their antiquity."

A table showing the known geographical and geological distribution, with the supposed relationships, of the several Equine genera is appended; and Madame Pavlow promises to supplement the work shortly by a memoir upon the Pleistocene horses of Russia.

The section (III.) upon the Rhinocer[ot]idæ and Tapiridæ is mainly a synopsis of the literature of the subject; and this appears to show that *Systemodon*, of the North American Eocene, is an immediate predecessor of the families under discussion, while *Hyrachyus* also is a missing link. A. S. W.

A PLEA FOR A UNIFORM SYSTEM OF ABBREVIATION WHEN QUOTING SCIENTIFIC PERIODICALS.

SIR,—It would be not only a great convenience to scientific students in general, but a much more satisfactory proof of the acquaintance of an author with the book he refers to, if some uniform system of abbreviation were adopted when quoting scientific literature. It is exceedingly perplexing to find variants in the abbreviation of a book-title, and has often caused considerable trouble and annoyance to those coming across them for the first time. A few years ago writers had some excuse for these and similar carelessnesses, inasmuch as no list of abbreviations had then been published, but when in 1874 W. Whitaker and W. H. Dalton issued the first volume of the Geological Record, they gave an excellent list of abbreviated titles, supplying the want of a book of reference, and leaving no excuse for "sloppy" quotation. This list has been further enlarged and improved in the volume for 1880-84, just issued, and may be taken, with very few exceptions,[1] as an absolutely safe set of abbreviations, each being distinct and

[1] It is always advisable to quote the *place* of publication in full in a scientific title.

definite. In the November Number of the Geological Magazine one cannot help being struck by the slip-shod system of reference used by two of the writers; *e.g.* "Tsch. Min. Mitt." is absolutely meaningless except to those who know the book; "Bull. Imp. Mosc." may refer to any Moscow society as no definite one is quoted.

Another source of inconvenience is seen in the reference to authors:—Prof. Judd, Prof. Bonney, Mr. Teall, etc., for example, how much more definite would it be to refer to these and any writer by initials as J. W. Judd, T. G. Bonney, J. J. H. Teall? We find much fault with our French and German colleagues for the vexatious system of printing surnames only, thus causing endless misquotation and confusion in library cataloguing, and yet ourselves permit it in our own scientific publications. The perfection of quotation, on the other hand, is seen on pp. 496–501 of the same number of the Geological Magazine, and proves unmistakeably that the writer is familiar with the books he refers to. C. Davies Sherborn.

CONE-IN-CONE STRUCTURE IN A COAL-SEAM.

Sir,—What is commonly known as "cone-in-cone coal" or "crystallized coal" has, I presume, nothing to do with true cone-in-cone structure here referred to. Through a friend of the writer's, a small concretionary mass of iron pyrites taken from the "Roaster" coal-seam near Ashby-de-la-Zouch, Leicestershire, has come into his hands for examination. Externally the specimen has very much the aspect of a roughly rounded pebble, and is nearly black in colour, measuring $1\frac{1}{2}$ inch in diameter, and about $\frac{3}{4}$ inch thick vertically. Having had the stone cut horizontally through the middle, cone-in-cone structure showed itself in places around the outside; in fact, the specimen appears to be nearly wholly made up of the same structure, though only at all well developed near the surface.

Whether the theory put forward by Mr. John Young, F.G.S., of Glasgow, and published in this Magazine, can or cannot account for the cone structure here seen, I leave others to judge; merely remarking that in my opinion some other explanation of the phenomenon must be found.[1] W. S. Gresley, F.G.S.

PROFESSOR THEODOR KJERULF.

Born March 30th, 1826; Died October 25th, 1888.

We regret to record the death, in Christiania, his native city, of Prof. Theodor Kjerulf, after a lingering illness. He was brought up and educated in Christiania, and after the completion of his University studies, spent some time in Iceland; he then went to Germany, where he studied in the laboratory of Bunsen, and at the same time pursued some geological investigations in the Harz and Tyrol. Returning to his native city, he commenced the study of the

[1] See W. S. Gresley, Note on "Cone-in-Cone" Structure, Geol. Mag. 1887, p. 17. John Young on "Cone-in-Cone" Structure, Geol. Mag. 1885, p. 283. Prof. J. S. Newberry on "Cone-in-Cone" Structure, Geol. Mag. 1885, p. 559. John Young's reply to Prof. Newberry, Geol. Mag. 1886, p. 139.

marvellous geological structure of the Christiania basin, of which the results appeared in the work entitled, "Das Christiania-Silurbecken, chemisch-geognostisch Untersucht" (1855). In 1858, Kjerulf became Professor of Geology in the University of Christiania, and shortly afterwards he initiated and organized the Geological Survey of Norway, to which he was appointed Director, and he continued to hold this post as well as the University Professorship till his death.

Dr. Kjerulf's most important work in connection with the Geological Survey, entitled "Udsigt over det sydlige Norges Geologi," appeared in 1879. In this the results of 20 years' observations of the Survey in the Southern part of Norway were summarized. The work was accompanied by an atlas of 39 plates and a geological map, and it is a mine of facts relating to the rock-formations of this country—from the Archæan gneiss to the Post-Glacial clays—their history, the fossils contained in them, the age and character of the eruptive rocks, etc. Dr. Kjerulf was also the author of numerous other important papers, mainly on the geology of Norway, which appeared at intervals between 1855–1885. Amongst these may be mentioned, "Ueber die Geologie des Südlichen Norwegens, mit Beiträgen von Tellef Dahll, 1857;" "Veiviser ved geologiske excursioner i Christiania omegn, 1865;" and "Ueber die Terrassen in Norwegen und deren Bedeutung für eine Zeitberechnung bis zur Eiszeit zurück," of which an English translation was made by Marshall Hall (Geol. Mag. 1871, pp. 74–76). Dr. Kjerulf, in his "Meraker profilet," and in several other Memoirs, has fully described the very interesting series of older Palæozoic and Archæan rocks in the district around Trondhjem, Roraas, etc. He was deeply interested in the glacial phenomena, so strikingly shown in Southern Norway, and in addition to several papers of his own on this subject, was associated with Dr. M. Sars in writing the "Iagttagelser over den Postpliocene eller Glaciale formation i en del af de sydlige Norge, 1860."

Dr. Kjerulf's services to Geological Science were known and appreciated far beyond his native land. He was chosen a Foreign Correspondent of the Geological Society of London in 1864, and Foreign Member in 1875.

THE LATE W. H. BAILY, F.L.S., F.G.S.

Sir,—In the Obituary of Mr. Baily, which appeared in the Geological Magazine for September last, p. 431, the List of his Works was omitted. I now send it for favour of insertion.—H.B.W.

1855.—1. Description of some Cretaceous Fossils from South Africa, collected by Captain Garden, Quart. Journ. Geol. Soc. vol. xi. pp. 454-465.
2. Description of Fossil Invertebrata from the Crimea, *op. cit.* vol. xiv. pp. 133-163.
3. On a Crustacean from the Coal-measures, with some remarks on the genus *Limulus*, Journ. Dublin Geol. Soc. vol. viii. pp. 89-91; Nat. Hist. Rev. vol. v. pp. 168-171.
4. Notice of Upper Silurian Fossils from Ballycar South, county of Clare, Journ. Dublin Geol. Soc. vol. viii. pp. 109, 110; Nat. Hist. Rev. vol. vi. pp. 72, 73.
5. On Carboniferous Limestone Fossils from county Limerick, Rep. Brit. Assoc. for 1857, Sections, pp. 62, 63.
6. On Fossil Localities near Drogheda, Journ. Dublin Geol. Soc. vol. viii. pp. 120-125.
1859.—7. On the occurrence of detached plates of the shell of a new species of *Chiton* in the Carboniferous Limestone at Lisbane, county of Limerick, Journ. Dublin Geol. Soc. vol. viii. pp. 167-171; Nat. Hist. Rev. vol. vi. pp. 330-334.

8. On the Fructification of *Cyclopteris Hibernica*, Forbes, from the Upper Devonian or Lower Carboniferous strata at Kiltorkan Hill, county Kilkenny, Rep. Brit. Assoc. for 1858, Sections, pp. 75, 76.

1860—9. On a new species of Pentacrinite from the Oxford Clay, Weymouth, Dorsetshire, Dublin Zool. Bot. Assoc. Proc. vol. ii. pp. 19-23.

10. On fossil *Chitonidæ* and their distribution in geological time, Dublin Zool. Bot. Assoc. Proc. vol. ii. pp. 40-47.

11. On a new species of *Solarium* from the Upper Greensand near Dorchester, Dublin Zool. Bot. Assoc. Proc. vol. ii. pp. 66, 67.

12. On *Corynepteris*, a new generic form of Fossil Fern; with observations on the associated plants from the Coal-measures of Glin, county of Limerick, Journ. Dublin Geol. Soc. vol. viii. pp. 237-241.

13. On *Sphenopteris Hookeri*, a new Fossil Fern from the Upper Old Red Sandstone formation at Kiltorkan Hill, in the county of Kilkenny; with some observations upon the Fish-remains and other associated fossils from the same locality, Rep. Brit. Assoc. for 1859, Sections, pp. 98, 99.

1862.—14. On the occurrence of some characteristic Graptolites and other fossils, indicating certain divisions of the Lower Silurian rocks in the counties of Meath, Tipperary, and Clare, Journ. Dublin Geol. Soc. vol. ix. pp. 300-306.

1863.—15. Baily, W. H. and A. Carte, Description of a new species of *Plesiosaurus*, from the Lias, near Whitby, Yorkshire, Journ. Dublin Geol. Soc. vol. iv. pp. 161-169.

16. On two new species of Crustacea (*Bellinurus*, Koenig), from the Coal-measures in Queen's County, Ireland; and some remarks on forms allied to them, Ann. and Mag. Nat. Hist. vol. xi. pp. 107-114.

17. Notes on the fossils collected by Mr. Wynne in the counties of Sligo and Leitrim, Journ. Dublin Geol. Soc. vol. x. pp. 40, 41.

1864.—18. On the occurrence of Fish-remains in the Old Red Sandstone at Portishead, near Bristol, GEOL. MAG. Vol. I. p. 293; Rep. Brit. Assoc. for 1864, Sections, pp. 49, 50.

1865.—19. On some new points in the structure of *Palæchinus*, GEOL. MAG. Vol. II. pp. 44, 45.

20. The Cambrian rocks of the British Islands, with especial reference to the occurrence of this formation and its fossils in Ireland, GEOL. MAG. Vol. II. pp. 385-400.

1866.—21. The recent discovery of fossil reptiles in the Coal of the south of Ireland, GEOL. MAG. Vol. III. pp. 84-86.

22. On Salter's Appendix to vol. iii. of the Memoirs of the Geological Survey of Great Britain, *ibid.* pp. 477, 478.

1867-1875.—23. Figures of Characteristic British Fossils: with Descriptive Remarks, vol. 1, Palæozoic, with 42 plates and 18 woodcuts. 8vo. London (Van Voorst).

1869.—24. Notice of Plant-remains from beds interstratified with the Basalt in the county of Antrim, Quart. Journ. Geol. Soc. vol. xxv. pp. 162.

25. Notes on Graptolites and allied Fossils occurring in Ireland, Quart. Journ. Geol. Soc. vol. xxv. pp. 158-162.

1871.—26. On the Fossils of the Ballycastle Coal-field, co. Antrim, Journ. Geol. Soc. Ireland, vol. ii. pp. 270-275.

1873.—27. Remarks on the Genus *Pleurorhynchus*, with a description of a new species (*P. Koninckii*), Journ. Geol. Soc. Ireland, vol. iii. pp. 24, 25.

28. Additional Notes on the Fossil Flora of Ireland. On *Filicites plumiformis*, n.s., from the Carboniferous Limestone near Wexford, Journ. Geol. Soc. Ireland, vol. iii. pp. 48-51.

1874.—29. Sketch of the Geology of Belfast and the Neighbourhood, Science Gossip, No. 116, pp. 169, 170.

30. Palæozoic Echinida: *Palæchinus* and *Archæocidaris*, Journ. Roy. Geol. Soc. Ireland, ser. 2, vol. iv. pp. 40-43. (2 plates.)

1875.—31. On Fossils from the Upper Old Red Sandstone of Kiltorkan Hill, in the county of Kilkenny, Proc. Roy. Irish Acad. ser. 2, vol. ii. pp. 45-48.

1876.—32. Description of a new species of Labyrinthodont Amphibian from the Coal at Jarrow Colliery, near Castlecomer, Kilkenny, Rep. Brit. Assoc. for 1875, Sections, p. 62.

1878.—33. Lists of Fossils in "Manual of the Geology of Ireland," by G. H. Kinahan, M.R.I.A., etc.

34. Sketch of the Geology of Dublin and Wicklow, Sci. Gossip, No. 164, pp. 179-183.

35. On the Palæontology of County Dublin, Journ. Roy. Geol. Soc. Ireland, vol. xv. pp. 78-98.

1879 & 1883.—36. Notice of some additional Labyrinthodont Amphibians and Fish from the Coal of Jarrow Colliery, near Castlecomer, county of Kilkenny, Ireland, Rep. Brit. Assoc. for 1878, Sections, p. 530, *op. cit.* 1883.

1880.—37. Report of the Committee appointed for the purpose of Collecting and Reporting on the Tertiary (Miocene) Flora, etc., of the Basalt of the North of Ireland, Rep. Brit. Assoc. for 1879, pp. 162-165.

1881.—38. Second Report, *ibid. op. cit.* 1880, pp. 107-109.

1883.—39. Third Report, *ibid. op. cit.* 1881, pp. 152-154.

40. Report on the Rocks of the Fintona and Curlew Mountain Districts (jointly with G. H. Kinahan, M.R.I.A.), Proc. Roy. Irish Acad. ser. 2, vol. iii. (Science).

1885.—41. On Trilobites and other fossils from Lower and Cambro-Silurian strata, in the county of Clare, Scientific Proc. Royal Dublin Soc. new ser. vol. iv. p. 373.

42. On a new species of *Orophocrinus* (*Pentremites*), in Carboniferous Limestone, county Dublin; also remarks upon *Codaster trilobatus* (M'Coy) from Carboniferous Limestone, county Kilkenny, Scientific Proc. Royal Dublin Soc.

1886.—43. Rambles on the Irish Coast, especially relating to the Geology, Natural History, and Antiquities in the neighbourhood of Dublin (map and ten woodcuts).

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